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JOHN L. RICH
EDITOR

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THE BULLETIN

of the

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JOHN L. RICH, *Editor*

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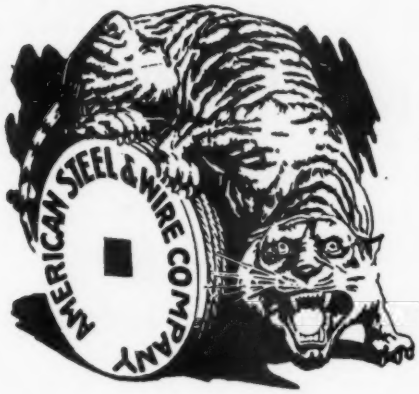

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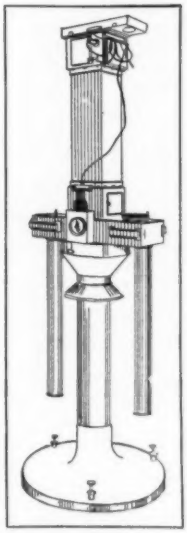

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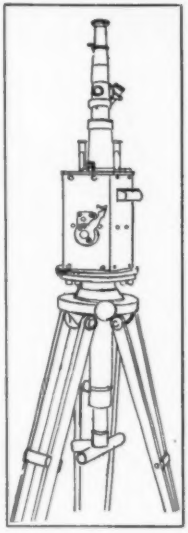

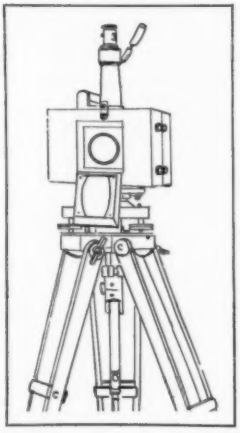

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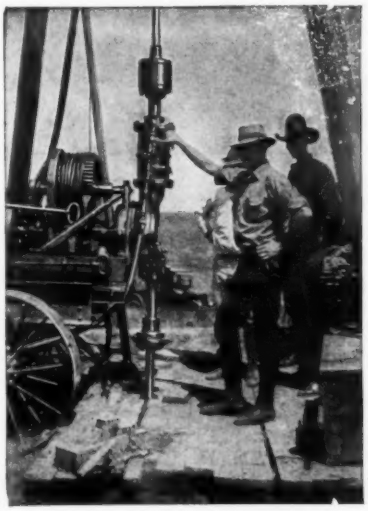

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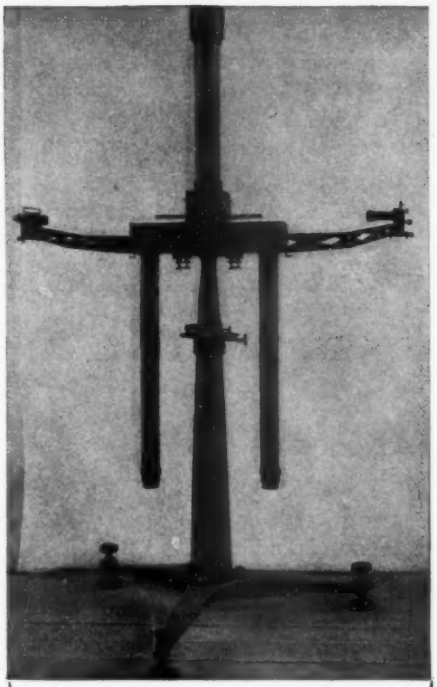

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MAY 1926

THE GEOLOGY AND OIL FIELDS OF ARCHER COUNTY, TEXAS

W. E. HUBBARD AND W. C. THOMPSON
Wichita Falls, Texas

ABSTRACT

Within the last three years Archer County, Texas, has risen from a position of relative unimportance as a producing area to one of the principal productive districts in the Mid-Continent field. At the present time there are 34 producing areas varying in size from pools of one or two wells to fields covering as much as 1,200 acres. Practically all of the production is confined to sand zones in the lower part of the Cisco group (Pennsylvanian) which are regionally persistent but locally very erratic. Development and operating costs are low, the oil is of high gravity (39–42 Baumé), and the wells are relatively long-lived.

The paper discusses the origin and accumulation of the oil as well as problems of porosity, ultimate yield, etc., of this particular district. Various tables show pertinent facts regarding individual fields and the relationship of surface to subsurface structure. Cross-sections show stratigraphic relationship of the fields and of the county to adjoining areas.

INTRODUCTION

GENERAL STATEMENT

During the past two years Archer County has become one of the important petroleum areas of Texas, having produced during that time at the rate of more than 30,000 barrels of high gravity oil daily. Practically all of the production comes from the middle portion of the Cisco formation, the uppermost member of the Pennyslvanian system of north-central Texas. The principal productive zone is present over a wide area although, locally, it is very lenticular and erratic. Drilling and development costs are low, with the result that the district has been a boon to the independent operator. Consequently, the county has been developed in a relatively short time.

HISTORY

The first oil well in Archer County was the No. 1 Andrews of Poppenburg and Miller, drilled in 1911 in the southeastern part of the county; it produced 10 barrels daily from a sand at 920 feet. Though this well was small, it caused considerable development by the Magnolia Petroleum Company, but after several dry holes had been drilled in the vicinity, the incident was forgotten. Interest was revived in 1916 by the completion of the Panther Petroleum Company's Wilson No. 1, south of Holliday, as a 20-barrel well from a sand at 1,630–1,636 feet. Drilling which had heretofore been sporadic was started in earnest but the results were disappointing since the pool included only a dozen wells and in the next five years over one hundred wildcats were drilled without a discovery.

The year 1921 marked the opening of the first Archer County field of consequence. In March of that year, the Texhoma Oil and Refining Company completed their Gose No. 1 as a 250-barrel well from a sand at 1,599–1,604 feet. The Texhoma-Gose field, as this area was later named, is about 7 miles southwest of the Panther pool, and still surpasses all Archer County pools in acre-yield of oil.

In August, 1922, the Freeman-Hampton field, important both for its size and the presence of three producing horizons, was discovered.

The spring and summer of 1923 saw the attainment by Archer County of an important place among the producing counties in Texas. In rapid succession, the Peterson, Swastika, Sunshine State, and Wilmot pools were opened and by fall the total daily production was about 40,000 barrels. This production has been essentially maintained during 1924 and 1925 by the addition of such pools as the Atlantic, Harmel, Ragle, and Carey, the latter including wells which produced over 1,000 barrels per day from a sand around 1,100 feet.

To date (September 1, 1925), Archer County has produced some 27,300,000 barrels of oil and is now maintaining a daily production of 33,000 barrels. New pools from the present known sands and development of deeper horizons should maintain this production for several years.

ACKNOWLEDGMENTS

The authors wish to acknowledge the helpful criticisms and suggestions of W. E. Pratt and F. H. Lahee, chief geologists of the Humble Oil and Refining Company and the Sun Oil Company respectively, and permission by them for the presentation of this paper. It is impossible to acknowledge in detail the assistance given by numerous others in discussions and interchange of ideas, but special credit should be given Messrs. J. V. Adams, Virgil E. Pettigrew, and A. J. Viets for assistance in the collection and assembling of data both in the field and office.

GEOGRAPHY

Archer County lies in the north-central Texas oil belt, in a position roughly midway between the eastern and western boundaries of the state and a short distance south of Red River, the Oklahoma boundary. It is bordered on the north by Wichita County and on the south by Young County, both of which are important producing areas. Clay County, known from the old Petrolia field, is on the east while Baylor County, which has recently become a small producing territory, lies to the west (Fig. 1).

Archer County lies in the semiarid plains region of northern Texas. The present land surface is a partially dissected peneplain. The drainage is toward the east through three main water courses trending north of east. The extreme northwest corner is drained by Wichita River, the southeast corner by the west fork of the Trinity and the remaining two-thirds of the county by the Little Wichita. Sea-level elevations range from about 900 feet at the point where Little Wichita River crosses the east boundary of the county to slightly over 1,300 feet in the vicinity of Megargel, 4 miles north of the southwest corner of the county. The slopes of the ridges between the water courses are gentle to the northwest and steep to the southeast due to the prevailing northwesterly dip of the rocks. The climate is one of extremes, the temperature ranging from 5° to 110° Fahrenheit. The annual rainfall is about 28½ inches. Due to the hot summer winds from the south and the insufficiency of the rainfall, farming is hazardous and most of the land is given over to cattle

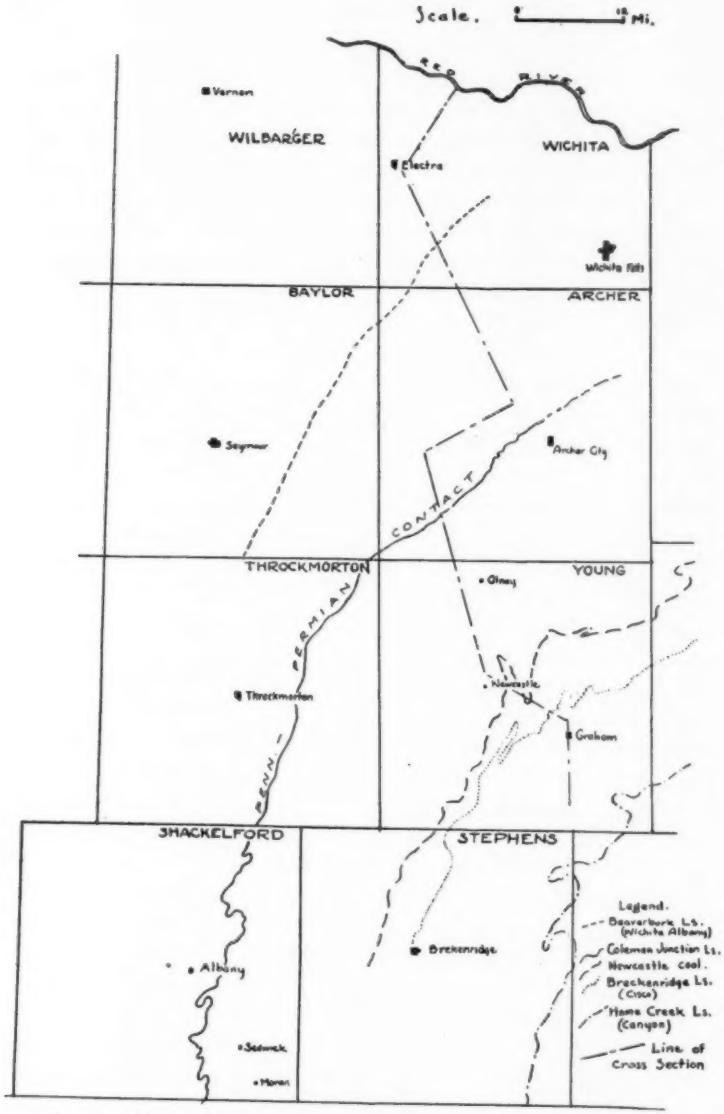


FIG. 1.—Map showing the Pennsylvanian-Permian contact and the outcrop of other key horizons in north-central Texas.

raising. The soil is varied in character, ranging from calcareous and sandy clay to pure clay.

The county is served by three railroads, the Wichita Falls and Southern which operates between Wichita Falls and Breckenridge, traversing the county from northeast to southwest, the Wichita Valley running across the northwest portion, and the Gulf Texas and Western cutting diagonally across the southwest corner.

There are no paved roads nor are good dirt roads numerous, so that in wet weather field transportation becomes a serious problem.

STRATIGRAPHY

Since interest in the Archer County area centers chiefly on the Cisco and Wichita-Albany formations, no attempt will be made to describe in detail the older Paleozoic rocks which are exposed south of Archer County. While these formations have a definite bearing on the geology of Archer County, little is known of their character in this area so far from their outcrop.

ELLENBURGER FORMATION

The Ordovician Ellenburger limestone, which may be considered the basement formation upon which the productive horizons of northern Texas were laid down, has as yet been unproductive. In the central mineral region of Texas, this formation consists of a few hundred feet of siliceous limestone while around the Arbuckle and Wichita Mountains in southern Oklahoma, the Arbuckle limestone, with which the Ellenburger is tentatively correlated amounts to several thousand feet of massive limestone.

BARNETT SHALE

Between the Ellenburger and the overlying Marble Falls limestone is the Barnett (lower Bend) shale of Mississippian age. This formation consists of dark gray and black shale, 50 to 150 feet thick which rests on a relatively flat surface of folded Ellenburger.

BEND GROUP

The basal Pennsylvanian Bend group is composed of two formations, the Marble Falls limestone below and the Smithwick shale

above. The Marble Falls limestone consists of about 200 to 600 feet of gray and black limestone with beds of black and green shale and is the source of the famous "black lime" production of Eastland and southern Stephens counties.

The Smithwick shale marks a transition from the limestone series of the lower Pennsylvanian to the more clastic materials of the overlying Strawn. The Smithwick is a black fissile shale, becoming more sandy and lighter colored toward the top; it is 200 to 400 feet thick. This formation thickens northward as does the Marble Falls with the addition of several relatively thin lime members. These latter beds are the source of the "gray lime" production of Stephens County.

STRAWN GROUP

At its outcrop, the Strawn group consists of sandstone, shale, and an occasional thin limestone. The maximum thickness as measured by Wells and McLeod at the outcrop is slightly over 3,800 feet.[1] The group thins westward being but 500 feet thick a few miles north of Coleman and is noticeably thinner along the axis of the Bend Arch. This group is also the principal coal-bearing division of northern Texas and is productive of oil and gas at various horizons in Eastland, Stephens, Young, Shackelford, and adjacent counties.

CANYON GROUP

The Canyon group consists essentially of limestone and shale, measuring typically 900 to 1,000 feet in thickness. It is composed of four massive limestone members, named from the top down: Home Creek, Ranger, Adams Branch, and Palo Pinto. These limestones form bold escarpments and are noticeable in well logs in areas far from their outcrop. By tracing some of these beds northeastward they may be seen to become more sandy, indicating a source of material from the north and northeast. The character of the Strawn beds below and the overlying Cisco indicate a similar source.

CISCO GROUP

The Cisco group, comprising the youngest Pennsylvanian of northern Texas is made up of alternating beds of sandstone, shale,

[1] F. B. Plummer and R. C. Moore, "Stratigraphy of the Pennsylvanian of North Central Texas," *Bur. of Econ. Geology, Bull. 2132*, 1921, p. 63.

and thin limestone, with several coal seams in the middle portion. Measured across its outcrop in Eastland, Stephens, and Young counties, it varies from 900 to 1,800 feet in thickness but it thickens rapidly northward from central Young County. The presence of chert conglomerate and many small local unconformities suggest rapidly oscillating shore lines during its deposition. It is conformable both to the Canyon below and the Wichita-Albany of the Permian above. The upper portion changes to a typical red-bed facies in northern Young, southern Clay, and Archer counties. It is the chief petroliferous series of the Pennsylvanian of north-central Texas.

The Pennsylvanian is represented in Archer County by approximately the upper 400 feet of the Cisco which outcrops in a triangular area, comprising the southeastern portion of the county.

For the most part, the section is of a typical red-bed character though in the extreme southwest corner where the uppermost portion is exposed, it closely resembles the Cisco in Young, Stephens, and Eastland counties to the south. In the section exposed, there are 26 well-defined sandstone horizons with chert conglomerate present locally. The sandstone beds are light to dark gray and brownish red, with a thickness of from 1 to 5 feet. The intervening shale is uniformly red.

The Coleman Junction limestone, regarded as the top of the Cisco, crops out in the Swastika and Harmel pools of southwestern Archer County. To the northeast it can be traced but a short distance due to the gradational change to red beds. However, the approximate position of the Cisco-Wichita (Permian-Pennsylvanian) contact across the county has been defined by the tracing of sandstone layers in the upper Cisco and basal Permian. Figure 1[1] shows the contact as worked out in this fashion. It will be noted that Archer City is shown to be within the boundary of the Cisco, where previously it has been assumed that but a small portion of the southeastern part of the county was covered by Pennsylvanian rocks. The average strike of the Cisco in southern Archer County is about N. 72° E. If this direction be used in projecting the contact eastward from the outcrop of the Coleman Junction near the Swastika pool,

[1] The authors wish to acknowledge information on the outcrops of various Pennsylvanian beds from Messrs. V. E. Pirini, Jr., and A. W. Johnson.

its trace will fall considerably south of Archer City. However, when it is remembered that Archer City and vicinity are about 300 feet lower in elevation than the Swastika pool, the reason for the change in location of the contact is apparent.

There is little surface evidence of an unconformity between the Cisco and Wichita and from subsurface evidence it appears that whatever unconformable relationships exist are as readily recognized within the formations themselves as at their contact.

PERMIAN ROCKS

The Wichita group in Archer County is represented by about 500 feet of intercalated light-colored to reddish sandstone and red shale not notably different in appearance from the red Cisco below. The sandstone beds are from 1 to 10 feet thick and from 10 to 35 feet apart although there is one 60-foot shale interval about 250 feet above the base of the section. The sandstone layers form good escarpments along the major streams and can be traced definitely for moderate distances though their lenticular nature renders exact measurement of intervals difficult.

The uppermost exposed division of the Wichita group is the Beaverburk limestone which crops out in a relatively small area in the extreme northwestern part of the county. This limestone, or more precisely, dolomite, is important as a key horizon and it can be traced southwestward to the south line of Baylor County where its interval above the Coleman Junction can be determined readily due to the limy nature of the intervening section in northeastern Throckmorton County.

PRODUCING HORIZONS

With scant exception all of the oil produced in Archer County comes from four definite zones in the Cisco known respectively as the Texhoma-Gose, Upper Wilmot, Dalmar, and Lower Freeman-Hampton pays. Their relative importance is indicated by Table I.

TABLE I

Sand	Number of Wells
Gose	1,689
Dalmar	12
Lower Freeman-Hampton	243
Upper Wilmot	94

TEXHOMA-GOSE SAND

The best-known and most productive pay zone in Archer County is the Texhoma-Gose sand, also variously referred to as the Archer County, Miller, and Swastika sand. It is productive in every field with the exception of the Dalmar, Shappell, and T. B. Wilson pools which are relatively unimportant. The depth of this sand ranges from about 900 feet in the Miller pool near the south county line to about 1,640 feet at the north edge of the county. It has produced about four-fifths of the county's production and bears an even larger ratio to the present daily total.

The stratigraphic position of the Texhoma-Gose sand is generally considered as directly beneath the Gunsight limestone (Fig. 4). The interval between the top of the Gose pay and the Coleman Junction limestone, the uppermost bed of the Cisco, is slightly over 1,300 feet in southern Archer County, 1,400 feet in central Archer County, and about 1,350 feet in the Electra pool of western Wichita County.

The sand is not continuous nor is the interval between it and the Gunsight limestone constant. It may occur any place within a 50-foot zone, which in turn lies from 1 to 20 feet below the lime. The pay sand varies from a mere streak to as much as 30 feet in thickness with the average for the county possibly 6 or 7 feet. The interval between the sand and the lime remains fairly constant within the limits of the various pools. In some sections there are two distinct pays some 40 or 50 feet apart. Abrupt changes in intervals and thicknesses occur locally from one location to another causing dry holes to be surrounded by good producers, and vice versa.

LOWER FREEMAN-HAMPTON SAND

Next in importance is the Lower Freeman-Hampton pay or the 1,750-foot sand of northern Archer County. It is the chief source of oil in the Freeman-Hampton and Orton pools and the only producing horizon in the Tad Wilson and Shappell pools. It is probably the 1,750-foot sand in the Kemp-Munger-Allen Pool and the 1,900-foot sand at Electra. Like the Gose sand, this pay is made up of two lenses locally (Freeman-Hampton pool) about 40 feet apart, the most productive of which is the upper one. The top of this zone lies about 160 feet below the Gose pay and the thickness of the producing sands

averages about 7 feet. With reference to the Cisco formation, it should lie a short distance above the Bunger limestone.

UPPER WILMOT SAND

The Upper Wilmot pay, occurring about 190 to 200 feet above the Gose horizon, is productive in the Wilmot, Peterson, Sunshine State, Oil Investment, and Freeman-Hampton pools and has produced about 5 per cent of the total oil of the county. Its interval above the Gose pay is tolerably constant in north-central Archer County but declines to 160 feet in the Freeman-Hampton area. In none of the fields in which it produces is its areal extent as great as that of the Gose sand nor in any pool is it as important economically. Its thickness is slightly less than that of the Gose pay. It probably lies not far above the Breckinridge limestone and hence may be correlated roughly with one of the pay horizons of Callahan County.

DALMAR SAND

The Dalmar horizon has been relatively unimportant to date. It is productive at 1,000 feet in the Dalmar and 1,100 feet in the Oil Investment pool. Its interval of a little more than 300 feet above the Gose sand places it approximately at the Newcastle coal horizon or about the equivalent of the second pay at Putnam in Callahan County. It carries considerable water (in the Oil Investment pool usually no more than a foot of sand can be drilled) and as there are but twelve wells producing from it in the county, its total production has been negligible.

OTHER SANDS

In addition to the pay zones described there are a few shallower sands of minor importance which produce in the Wilmot, Holliday, and Freeman-Hampton pools of northern Archer County. The 900-foot sand in the north end of the Wilmot pool lies 700 feet above the Gose sand, placing it in section between the Camp Colorado and Dothan limestones. It has afforded several wells of more than 100 barrels initial production. Two higher horizons, respectively 820 and 930 feet above the Gose sand, produce in scattered areas near the towns of Holliday and Mankins. None of these three sands have

been thoroughly tested in the producing areas of northern Archer County and their exploitation can be expected to add a fair percentage of production to the total oil recovered from the various fields.

Only the Gose or Swastika sand is productive in the fields of south Arther County but in at least two wells, the Barclay No. 1 Wright east of Megargel and Rayzor No. 1 Porter south of the Green-Flowers pool, a sand slightly less than 250 feet above the main pay has been noted. This is probably the equivalent of the Dalmar or Upper Wilmot pay.

RELATION OF SAND BODIES TO SOURCE OF OIL

The depositional nature of the producing zones is indicated in a graphic manner by production maps of many of the fields. Large producers offset dry holes in the very heart of some of the pools and the sands pinch out from a thickness of 15 or 20 feet to less than a foot in a very few hundred feet. This rapid and erratic gradation from sand to sandy shale and shale and the common occurrence of cross-bedding indicate constantly changing currents and rapidly shifting shorelines (Fig. 2).

A study of the Gose horizon as it has been correlated with an outcrop one-half mile west of Graham in Young County (Figs. 3 and 4) reveals that the shale below the sand is rich in carbonaceous material and, as far as observed, devoid of marine fossils, while the sand itself contains fossils undoubtedly marine in origin. This succession suggests a tidal flat or lagoonal origin for the shale and a marine one for the sand, probably caused by an advancing bar or barrier beach over a coastal marsh. In many wells coal is logged a short distance below the sand, which is a further indication of the terrestrial origin of the shale at least in part. The writers are of the opinion that the oil, or perhaps more properly, its parent substance, originated mostly in the shale below the sand probably not long after its deposition and during the subsequent compacting was literally squeezed from the mud into the sand along with the connate water. In support of this belief in an upward rather than a downward migration, we suggest that an upward direction should ordinarily be the line of least resistance in sediments, the porous mem-

bers of which are very lenticular, inasmuch as during the compacting process, the underlying sediments are invariably more compacted and hence more impervious than those near the top.

However, should a thick continuous sand underlie the source rock and by virtue of its permeability afford an easier escape for

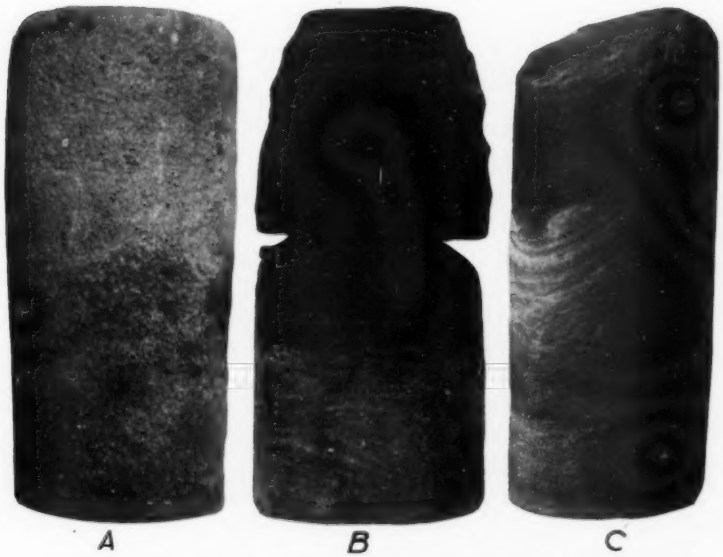


FIG. 2.—Cores of sands from north-central Texas. (*A*) Sand at 1,578–1, 579 feet from Gose No. 21, Texhoma Gose field (courtesy I. R. Sheldon). (*B*) Sand at 1,588–1,589 feet from Gose No. 33, Texhoma Gose field (courtesy I. R. Sheldon). (*C*) A typical sand core sample from a northern Archer County well.

the connate water it is clear that the migration might well be downward. As noted, this situation does not obtain in the sediments under consideration.

As the writers know of no appreciable faulting in the Cisco of Archer County, it is assumed that once the oil has migrated into the sand, it remains there, further movement being controlled by the structure of the particular sand lense.

NATURE OF OIL SANDS

The oil sands are composed almost entirely of subangular to poorly rounded transparent quartz grains with occasionally glauconite and more rarely some of the heavy minerals present. The degree

FIG. 3.—Outcrop of Gunsight limestone (*X*), west of Graham, Young County, Texas.

FIG. 4.—Outcrop showing Gunsight limestone and underlying sandy beds, west of Graham, Young County, Texas.

of cementation is slight and the sands are normally soft and friable.[1] The matrix is composed chiefly of calcareous and clayey material. When not stained with oil, cores of the sand have a characteristic light-gray color.

A rather high degree of sorting usually prevails in the sands from producing wells. An average for samples of the Gose sand from eight producing wells shows the following composition as to size of grain.

2–1 mm.	1–½ mm.	½–¼ mm.	¼–⅛ mm.	⅛–1/16 mm.
0 per cent	24 per cent	46 per cent	29 per cent	1 per cent

POROSITY

Porosity determinations were made by referring the specific gravity of various core fragments (corrected for the percentage of oil in the samples) to the specific gravity of the solid mineral matter in the cores. Using this method for characteristic core samples from nine wells, an average result of 22.8 per cent was obtained, the range being from 19.4 to 24.6 per cent.

OIL RECOVERY

The percentage of recovery from the sands varies greatly. One large lease in the Texhoma-Gose field will produce between 10,000 and 13,000 barrels per acre with an average sand thickness of not more than 10 feet, indicating a recovery of from 58.5 to 76 per cent.

In the Freeman-Hampton pool, 48 acres are productive in the 1,440-sand, 282 acres in the 1,580-foot sand, and 590 acres in the 1,740-foot sand, a total of 940 acres. The average sand thickness for the 940 acres is 8 feet, and the estimated gross ultimate production for the field is 7,520,000 barrels or 8,000 barrels per acre. Assuming the percentage of pore space to be 22.8 per cent, a recovery of 56.5 per cent is indicated. Many areas will undoubtedly fall well below these figures but the average for the county should probably be about 50 per cent.

No general statement of acre yields will be applicable to separate pools. Estimates for the Texhoma-Gose and Freeman-Hampton

[1] In a few instances, the producing zone is a porous coarsely crystalline limestone. Notable examples include the Coody Ranch south of Archer City, the Sun Oil Company Famer No. 1, and the Brader pool.

pools, cited above, will likely be somewhat above the average. Based upon present producing acreage, total production to date, probable future production of wells now producing, the average production per acre in Archer County should be slightly in excess of 7,000 barrels.

STRUCTURE

REGIONAL STRUCTURE

The major structural feature of Archer County is a broad north-plunging arch trending from south to north through the center of the county. Evidence of this is present in both the Cisco and Wichita groups. Local flank folds, both surface and subsurface, plunge away from the axis of this major arch, while those near the crest generally plunge northward down the pitch.

As the prevalent dip of the upper Pennsylvanian and lower Permian is a gentle one to the northwest the reflection of the easterly limb of the fold is largely evidenced by either an arresting of the normal dip or a change of this regional dip from northwest to north, although in northeastern Archer County dips to the northeast are sufficiently numerous to postulate a regional dip in this direction.

Generalized subsurface contours (i.e., lower Pennsylvanian, Fig. 5) of the area between Stephens County and Red River show that the folding noted above is intimately associated with a prolongation of the axis of the Bend Arch and can well be assumed to be a reflection of the latter.[1] Indeed, there is much evidence to show that the Bend Arch, after swinging to the northwest in northern Archer County, joins with the Red River Arch near the Electra pool. Again the distribution of the Seymour (Tertiary) gravel suggests that the axis of the arch was comparatively high during the deposition of the former or else subsequent folding subjected this formation to more erosion along the axis thus leaving remnants of it only in the synclinal areas.

From the foregoing it is patent that the regional folding has been cumulative in that the movement which started in Bend time has

[1] Why this reflection of the Bend Arch is not as strong in the surface beds farther south, i.e., the lower Cisco and Canyon of Stephens and Eastland counties is a problem for future study but the general change in strike from northwest to northeast in northeastern Archer County may be largely due to the influence of the Red River Arch.

continued more or less along the same lines of weakness causing the dips to become progressively steeper with depth.

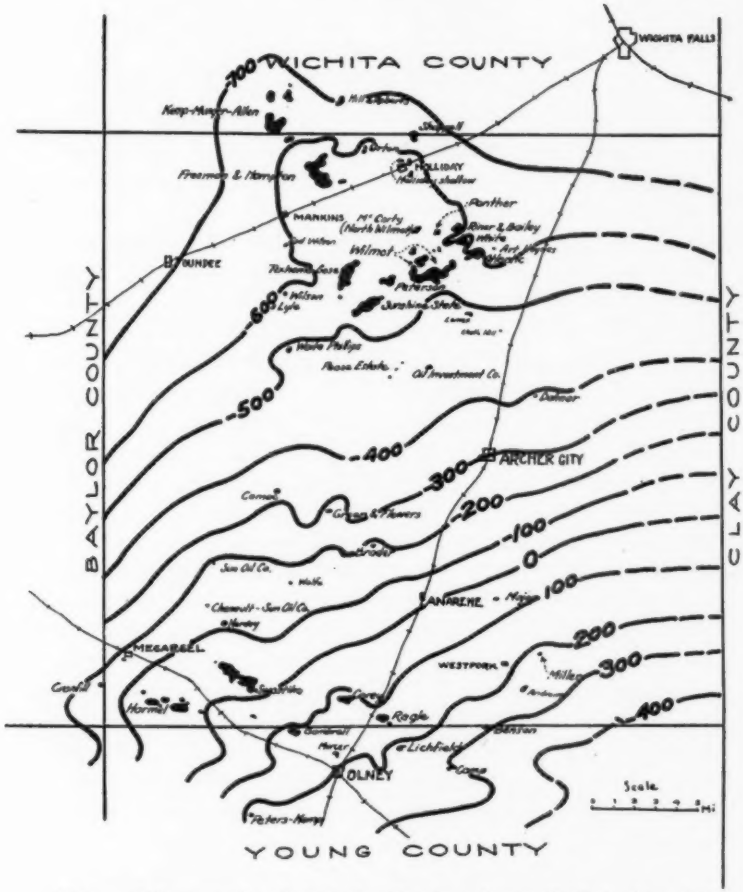
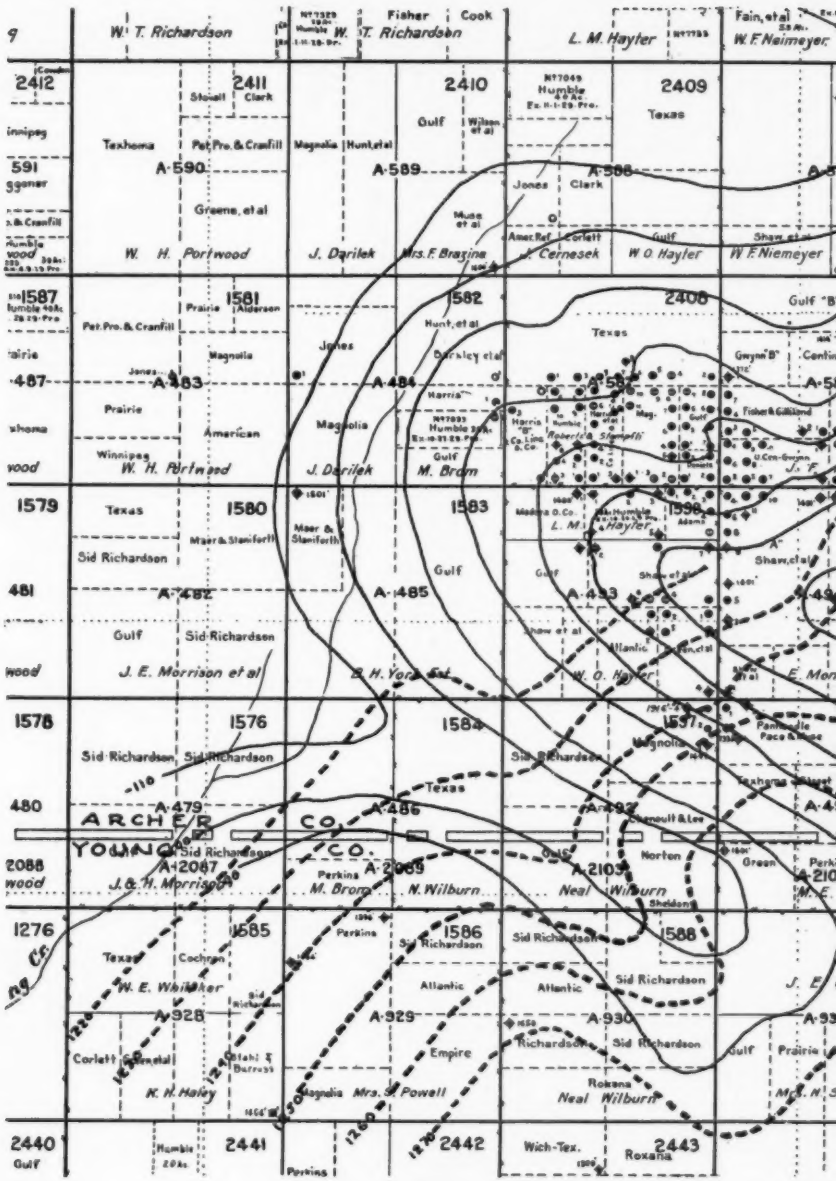


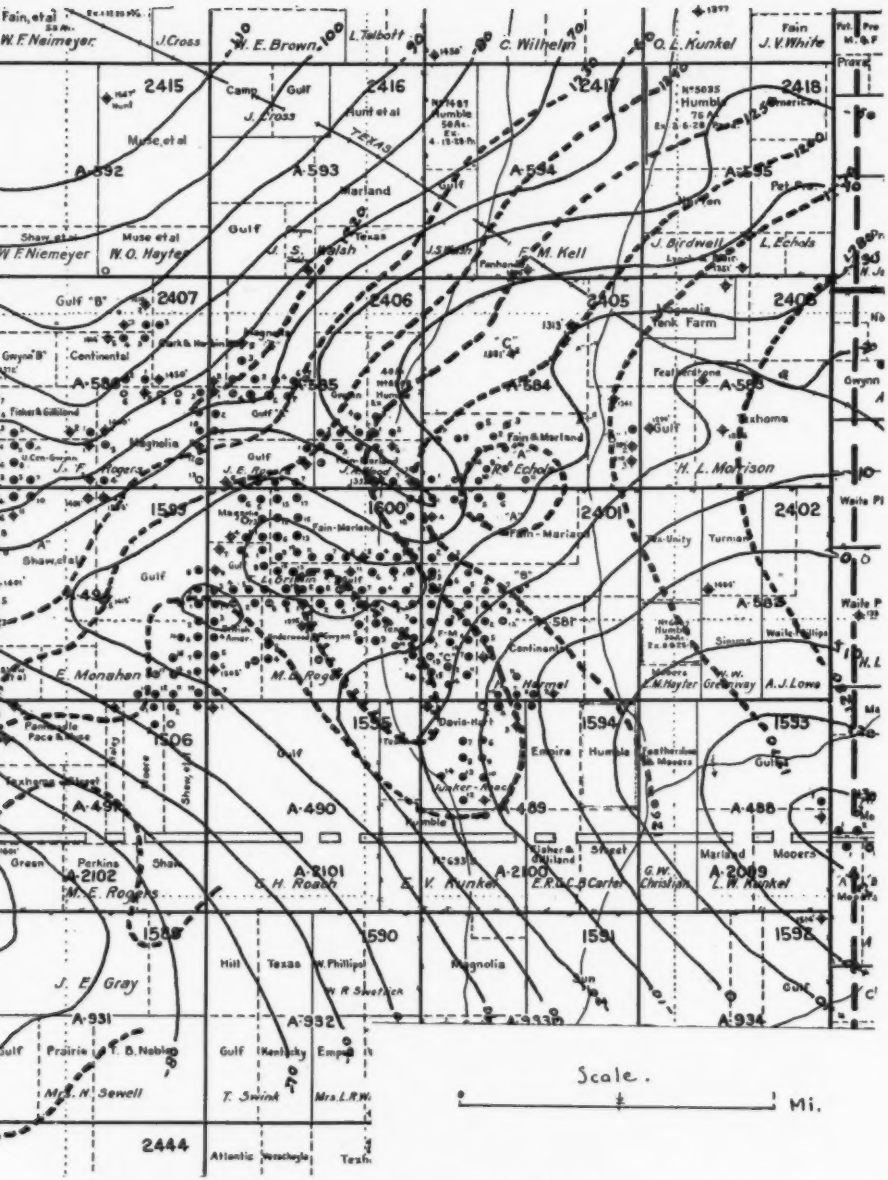
FIG. 5.—Index map of pools in Archer County and generalized structure of the main pay sand.

The producing fields of Archer County seem to group themselves along the axis of this hypothecated extension of the Bend Arch,



SURFACE AND SUBSURFACE STRUCTURE OF THE HARMEL AND STA

Surface contours (dashed) on the Coleman Junction limestone. Subsurface (solid) on



EL AND STAMPFLI-ROBERTS FIELDS OF SOUTHWESTERN ARCHER COUNTY

ce (solid) on top of pay sand. (Surface geology by M. M. Garrett and Charles P. McGaha).

with their major axes, in turn, generally normal to the direction of the general strike in the area in which they are located.

LOCAL STRUCTURE

The surface rocks of Archer County, while not strongly folded, have been subjected to influences that have given rise to numerous folds which may be noted in any area where sufficient outcrops are present. The predominant type of surface fold is a small plunging anticlinal nose or terrace, usually without closure and with never more than 10 or 15 feet of closure. The axial direction, as in the case of the pools, is variable but normally in the direction of the prevailing dip in the particular area. Contrary to the views of some geologists, the authors are of the opinion that these surface folds are not a reliable index of subsurface conditions, and that surface detail mapping is of little value in locating new fields.

Some fields have been opened up by wildcat tests drilled for the purpose of testing surface structures but in such cases subsequent development has shown that production covered large areas extending indiscriminately over the high and low areas of surface folding and, as often as not, with the surface folds overlying subsurface synclines and vice versa. A good example of this condition may be illustrated by the Harmel pool of southwestern Archer County. This area is chosen because the surface structure may be worked accurately using the Coleman Junction limestone as a datum. Two very pronounced surface folds lie on either side of this field and while small production extends over one of them, the heart of the field and the high point of the subsurface fold lies immediately below the lowest area on the surface (Plate 14).

Of a list of twenty-two surface folds in the county, chosen because they are generally recognized as such, drilling has revealed that seven overlie subsurface lows, five overlie normal subsurface areas, and but five are over subsurface highs. Based upon this analysis and also a study of the surface conditions overlying the producing areas, we feel confident that subsurface highs lie indiscriminately below anticlinal, synclinal, and monoclinal surface folding. Accepting this assumption, the great majority of surface folds either play out with depth or at least bear only the most general relationship to pre-

existing folds. Of the ones which disappear with depth probably the greatest number are settling folds.

In an area of such uniformly gentle dips, the origin of the surface structures must be accounted for in some other manner than by stresses derived from distant mountain areas. It is hardly to be expected that sediments such as those on the surface in Archer County could transmit stresses necessary to account for uniform folding. Furthermore, the lack of uniformity between the surface and lower Cisco beds argues against folding of this nature.

Subsurface folds in general may be classified much the same as the surface except that the former are usually more intense, having from 10 to 30 feet of closure and exhibiting more definite axes. The direction of the subsurface axes is apparently governed by the same condition as the surface folds. The intensity of the folds is due in many cases to thickening and thinning of sands since it is often noted that edge wells in a given field will not have any sand while inside wells a few locations away will encounter a considerable thickness. In such cases the lime cap above the sand is lower to correspond with the absent sand.

In view of the similarity of both surface and subsurface structures, it is entirely possible that they were formed under similar conditions. The regional structure and stratigraphy are such that this could have been the case and still leave the two sets of folds unrelated as to relative position of their axes. Since in most cases the axis of both sets of folds is away from the main axis of the Bend Arch it follows that the folds themselves must be accounted for by other forces than those which lifted the arch. The writers are of the opinion that most of the folds of Archer County, especially those on the surface, were formed in the following manner: (1) settling, including differential compacting of sediments, (2) deposition, (3) folding incident to a shortening of beds in a subsiding area. It is obvious that the foregoing conditions would not affect sediments through any great thickness with sufficient regularity to make surface and subsurface beds conform.

PRODUCTION AND DEVELOPMENT

In connection with the consideration of development methods and production of Archer County, it is interesting to note the magnitude

of the operations that have taken place. To date there have been drilled in Archer County some 3,200 holes of which 2,000 have been productive and the remainder dry. The depth of these holes ranging from 900 feet in the southeastern part of the county to something over 1,700 feet in the northern part, probably averages close to 1,500 feet. With drilling costs and equipment costs for producers considered, it is thought that the money spent for development will run close to $7.00 per foot or a total of over $31,000,000. Although these figures are necessarily an estimate, they serve to give some idea of the amount spent in this area. Table III gives a summary of the principal pools of the county.

TABLE II

Year	Production	Year	Production
1917.....	44,522	1922....	848,370
1918.....	79,000	1923....	5,261,596
1919.....	58,230	1924....	11,185,732
1920.....	54,192	(To 9/1) 1925....	9,300,000
1921.....	436,146		
		Total.....	27,361,788

From the first commercial production to September, 1925, Archer County has produced over 27,300,000 barrels of oil. The production of Archer County by years from 1917 to date is as shown in Table II.

While this oil has been produced over a wide territory and from several different sands, the character and gravity is more or less constant. The gravity ranges from 37° to 41° Baumé with an average of about 40°. In some instances it is light brown in color but usually it is green. The yield from straight refining methods is, gasoline 43 per cent, kerosene 8.0 per cent, gas oil 21.5 per cent, and fuel oil 27.5 per cent.

DRILLING METHODS

The thoroughness and rapidity with which Archer County has been tested is due largely to the easy operating conditions and consequent low costs. This feature has been a boon to the small independent operators who are exceptionally active in this district. By the sale of a few tracts near his test to the large companies, the independent usually completes a well without any great cost to himself. The Archer County district offers a striking example of the successful co-operation between the independent operators and the major companies.

Practically all wells are drilled by the rotary system. The common procedure is as follows: A large hole, 12- or 13-inch, is started and carried down a sufficient depth for a surface conductor which usually consists of a joint or two of 10- or 12-inch pipe, or a wooden box made of 2×12-inch lumber. A 9⅞- or

TABLE III

ARCHER COUNTY OIL POOLS*

Pool	Date	No. Acres	Prod. Wells	Dry Holes	Sand Depths	Sand
Atlantic	5-10-24	131	41	12	1,550	1
Barkley-Meadows	11-17-23	50	13	4	1,570	1
Brader	6- 4-23	26	5	4	1,260	1
Burns & Maxson	5-13-25	55	13	5	1,415	1
Carey	10-11-24	208	75	22	1,100	1
Comac	4-20-24	65	13	6	1,460	1
Dalmar	5- 5-22	20	4	2	1,020	3
Freeman-Hampton	8- 1-22	940	306	36	1,440–1,580–1,740	1–2–4
Green-Flowers	4- 5-25	48	8	4	1,400	1
Harmel	9-11-24	731	188	46	1,300	1
Humphrie (White)	6-14-24	291	78	17	1,400–1,590	1–2
Ikert	2-12-25	40	15	4	1,270	1
Major	5- 3-24	40	13	3	1,020	1
McCarty	5- 2-24	71	21	6	1,580	1–900′
Miller	10- 7-11	25	4	4	900	1
Muse-Robertson	5- 6-25	50	17	4	1,200	1
Norday	6-18-25	55	18	6	1,400	1
Oil Investment	11-22-24	80	23	6	1,105–1,205–1,415	3–2–1
Orton	4-16-24	81	17	5	1,430–1,590–1,800	1–2–4
Panther	8- 6-16	48	10	11	1,600	1
Pease	7-12-24	5	2	3	1,470	1
Peterson	3- 3-23	248	87	8	1,380–1,580	1–2–900′
Ragle	6-21-24	231	75	11	1,090	1
Riner-Bailey	1- 5-24	225	75	14	1,620	1–2–900′
Shappell	2-13-23	185	29	6	1,800	4
Stampli-Roberts	11-20-24	250	78	29	1,350	1
Sunshine	5- 1-23	420	122	10	1,380–1,580	1–2
Swastika	5-12-23	451	166	41	1,350	1
Texhoma-Gose	4-15-21	513	87	15	1,600	1
Waite Phillips	8- 5-24	75	25	7	1,500	1
Wilmot	6- 6-23	1,282	387	39	1,380–1,580	1–2–900′
Wolfe	4-11-25	15	3	1	1,370	1
Tad Wilson (Howard)	4-18-25	40	7	4	1,700	4

1—Gose, 2—Upper Wilmot, 3—Dalmar, 4—Lower *F-H*

* During the first eight months of 1925, 592 producers have been completed with an average initial production of 97 barrels (Table II).

9¼-inch hole is then started and carried to within a few feet of where the sand is expected. A 6-inch bit is then used until the sand is encountered, which is usually under a lime cap from 1 to 4 feet thick and from 1 to 15 feet of gumbo. Most of the drilling is done with fishtail bits although in the south Archer County fields it is necessary to drill some of the harder lime beds with a rock bit.

If the well is a wildcat, cores are taken to determine the character and amount of the sand. If in a producing field, 6⅝-inch casing is set after drilling a foot or two and catching the cuttings to be sure that the sand carries oil. When the sand depth has been determined, the hole is reamed down to within 2 or 3 feet of the sand and a casing seat made, in shale or gumbo if possible, with a diamond point or V-shaped fishtail bit dressed to about 7 inches. The 6⅝-inch casing is run with an ordinary casing shoe, usually without a packer and in most pools is not cemented. The casing shoe wedges into the cone-shaped hole made by the diamond point bit and usually makes a water-tight seat. The seat may be tested by applying pressure through the mud pumps. After bailing the hole to test the casing seat, the well is drilled in, either with or without mud, depending upon the amount of oil that comes into the hole after the first bailing. Practically every well presents an individual problem since there is no critical water level in the area and there is very rarely a general rule even in small areas as to the depth into the sand a well may be drilled. It is a general failure of operators to drill too deep into a sand and get water sooner than it would otherwise be produced.[1] Water thus encountered does not always kill the well, and in fact may be overcome for a time since it is often noted that water production shows a decline faster than the oil in the early life of a well. However, it is thought that more oil will be recovered and the troublesome factor of water more nearly eliminated where a reasonable amount of sand is drilled.

The early behavior of the producing wells is variable. Initial production ranges from a very few barrels to over a thousand daily. Due to low rock pressures and the small amount of gas present, a majority of the wells do not flow, although the oil rises vary rapidly in the hole to within a few hundred feet of the top. Many wells of this character have been swabbed at the rate of 700 to 800 barrels per day and later pumped through 3-inch tubing at the rate of 400 to 500 barrels daily. Again other wells which have flowed from 5 to 10 barrels on completion have yielded no more than this amount when placed upon the pump.

The first wells in any field are pumped from the beam after standardizing, but after a lease has been developed, all wells are pumped by an ordinary pumping jack operated from a "power." From fifteen to twenty-five wells are often pumped in this manner making lifting costs relatively low.

The following figures give a general idea of costs for wells of various depths ready to be standardized. It is to be understood that these estimates are rather generous and these figures may be cut materially by experienced operators. Economies may be effected by skidding derricks from one location to another

[1] Conditions with respect to water problems vary with the different pools. In some fields wells not necessarily the highest structurally may be drilled 10 and 15 feet into the sand, and water will not appear for several months. On the other hand, in pools like the Oil Investment and T. B. Wilson (Waite Phillips) only a foot or two of sand may be drilled before water is encountered.

and on the time required for drilling during the development of a field. These prices include actual costs for the time allowed and give a sufficiently general estimate to include all conditions.

COSTS FOR 1,600-FOOT HOLE

Contract price at $3.00 per foot	$ 4,800
Day work (completing well, running tubing, etc.)	300
Fuel 20 days	1,200
Water 20 days	300
Derrick	675
Casing 1,600 feet 6⅝-inch	2,400
Incidentals (slush pit, water pumper, etc.)	325
	$10,000

COST FOR 1,000-FOOT HOLE

Contract price at $3.00 per foot	$ 3,000
Day work	300
Fuel 12 days	720
Water 12 days	180
Derrick	675
Casing 1,000 feet 6⅝-inch	1,500
Incidentals	325
	$6,700

(For dry hole deduct casing costs)

POSSIBILITIES OF DEEP PRODUCTION

The past few years have seen a development of deeper horizons in many of the older fields of the Mid-Continent where the original producing beds have been drilled up. Since the first important development began, the shallow sands of Archer County have demanded all of the attention of the operators but with the depletion of these pools more attention will be turned to the development of deeper zones that are thought to exist. As yet, only a few scattered tests have been drilled below the base of the Cisco and of these none can be said to be in a well-selected area. With formations that produce elsewhere known to exist under Archer County, it will only be a matter of time and proper encouragement of operators by general conditions, until these beds will be tested and there is every reason to believe that important production will be developed from them.

Of the total oil produced to date in northern Texas, Cisco forma-

tions have produced roughly 53 per cent, Bend 43 per cent, and Strawn 4 per cent. Although the Cisco formation has produced more than half of the oil recovered, deeper formations will furnish reserves when the Cisco horizons have been depleted. Furthermore, it is possible that more prolific production will be developed from relatively unimportant horizons or from beds not now producing.

STRAWN

The Strawn group merits a position of first importance in any consideration of deeper possibilities. Although it does not rank as a producer with the Cisco or Bend, its petroliferous facies are of the greatest extent and it is a productive series that covers a wider territory than any other division of the Carboniferous. The producing horizons within the Strawn maintain a marked persistence in interval below the top of the formation. The first important sand comes a little more than 100 feet below the Palo Pinto limestone (basal Canyon) (Fig. 6). This horizon, the Turkey Creek sandstone, has produced oil and gas in the Ibex and Moran fields of Shackleford County. Showings were also recorded from this horizon in the Bashara well in western Young County. In the Bunger and South Bend fields of southern Young County, the 1,900- and 2,100-foot sands come 800 and 1,000 feet respectively below the Palo Pinto. Small production has been developed in a sand 875 feet below the base of the Palo Pinto in the Bashara Morgan well of western Young County. This latter horizon has produced in the Holleman field and on the Scott lease in the Olden Shallow field. Here it is called the Scott sand and occurs 830 feet below the Palo Pinto. In the Humble Stubblefield well of southeastern Throckmorton County, the sands at 639 and 865 feet below the Palo Pinto have carried good showings.

With these widespread showings in well-defined horizons, it does not seem unreasonable to expect that when the search for deeper oil is carried to the Strawn in Archer County, important production will result.

CANYON

Although the Canyon group is predominantly a lime and shale formation and at first thought could not likely be considered a

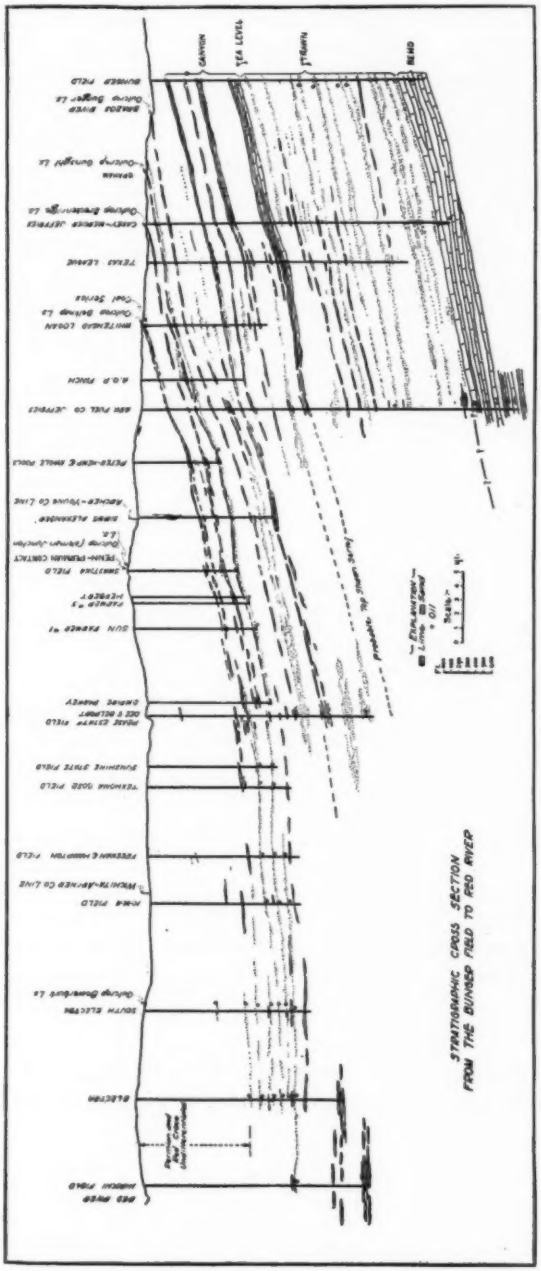

CANYON
TEA LEVEL
STRAWN
BEND
EXPLANATION
Lime
Sand
Oil
Scale
STRATIGRAPHIC CROSS SECTION
FROM THE BUNGER FIELD TO RED RIVER

FIG. 6.

potential producing formation, it is not without distinct possibilities. Both well logs and surface outcrops indicate a change in character of the sediments northward and northeastward and apparently some of the massive lime groups are completely replaced by sand. For this reason it is entirely possible that at some point these sands will carry oil. At several localities in Brown County, shallow oil is present in the Canyon and in one well in Archer County, the Dee and Bellport No. 1 Cowan, a gas show was recorded from a sand at 2,800 feet. As near as it can be correlated, this sand would fall near the base of the Canyon. With the Canyon beds as with other formations which do not crop out in Archer County, definite information as to character and extent is lacking but with such a thickness of beds within reasonable drilling depth, the Canyon offers a distinct possibility for the future.

MARBLE FALLS

Big lime production in Archer County based on recent costs and values of crude would be unprofitable. The top of the Marble Falls should normally lie at depths of 5,000 feet in southeastern Archer to 6,000 feet along the Wichita line. The Silk well, however, ten miles north of the southeast corner of the county, was drilled to 5,005 feet without penetrating the Marble Falls but was supposedly in the top Bend when abandoned. It would, therefore, either be low on the east flank of the Bend Arch or represent a thickening of the lower Strawn and possibly Smithwick northward from central Young County. We are inclined to the former view though no other deep wells have been drilled in the county to establish either theory. It is probable that the Marble Falls limestone or its equivalent underlies the entire county though no direct proof is available.

SMITHWICK

The producing horizon at Breckinridge and vicinity, the "gray lime," is recognized as a lime horizon in the Smithwick shale about 300 feet above the Marble Falls. The same analysis as the one suggested for the Marble Falls would apply except for the somewhat lower depth. Production of some sort could be expected but only at a loss under present economic conditions.

CORRELATIVE VALUE OF THE MICROLITHOLOGY AND MICROPALEONTOLOGY OF THE OIL-BEARING FORMATIONS IN THE SUNSET-MIDWAY AND KERN RIVER OIL FIELDS

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ABSTRACT

This paper deals with some results of a microscopic study of surface samples and core samples taken from exposures of oil-bearing formations and from certain wells drilled in the Sunset-Midway oil field and in a region north of Bakersfield.

The correlative value of various lithological characteristics and the microfossils found in the formations is considered. A possible stratigraphical division of the formations is described, and several examples of well correlations by microlithology or micropaleontology, or both, are given.

INTRODUCTION

During the last year a microscopical study of the San Joaquin oil-bearing formations was undertaken by the writer for the purpose of stratigraphical correlation. Both from the general paleontological point of view, also from personal knowledge of the results of Dr. J. J. Galloway's work on foraminifera in Mexico, and still more from the same kind of work successfully started in the Los Angeles basin by Mr. George H. Doane, the writer had no doubt, and still believes, that in case one is dealing with formations carrying a good foraminiferal fauna, correlations based upon these micro-fossils are reliable and satisfactory.

The first examination of samples from wells and outcrops in the Sunset-Midway oil region showed, however, that although foraminifera occurred throughout all the formations, associations of the microfossils sufficiently abundant and diverse for correlative purposes were confined to only a few zones of comparatively small thickness. Therefore it became clear that the foraminifera alone could not furnish a good basis for correlation, but would prove very valuable when supplemented by microlithology, which had already been

advocated by R. D. Reed,[1] F. G. Tickel,[2] A. C. Trowbridge, and M. E. Mortimore[3] as a means of correlation.

METHODS USED

When the writer began the study of foraminifera he realized that there was no commonly accepted and exact criterion for the classification of foraminifera by species. Therefore it was necessary to decide which characteristics of the specimens found in the examined samples and belonging to one and the same genus should be considered as really determining different species and which as representing only minor mutations dependent upon factors of little importance.

In order to make a uniformly recorded and easily visualized analysis of the foraminifera the following method was devised. In dealing, for example, with a number of specimens of foraminifera belonging to the genus *Rotalia*, it may be found that one differs from another in (1) the shape of the dorsal side, (2) the shape of the ventral side, (3) the shape of the margin, (4) the character of the sutures on the dorsal side, (5) character of the sutures on the ventral side, (6) the position of the aperture, and (7) the number of chambers in the last coil. All the possible combinations of these differences may be recorded easily by symbols of seven digits, so that the first digit indicates one or another shape of the dorsal side, the second served for recording variations in the shape of ventral side, and so on. An illustration of this scheme is given in Table I.

A list of specimens found in each sample and indicated by the symbols just mentioned gives a very clear idea which of the variations observed always occur together, and which show a certain independence with respect to the others.

An application of this method to a study of the foraminifera found in the samples from the Lower Etchegoin showed that, among the specimens which the writer first classified as belonging to four

[1] R. D. Reed, "Rôle of Heavy Minerals in the Coalinga Tertiary Formations," *Economic Geology*, Vol. 19 (December, 1924), No. 8.

[2] F. G. Tickel, "The Correlative Value of the Heavy Minerals," *American Association of Petroleum Geologists*, Vol. 8, No. 2.

[3] A. C. Trowbridge and M. E. Mortimore, "Correlation of Oil Sands by Sedimentary Analysis," *Economic Geology*, Vol. 20 (August, 1925), No. 5.

TABLE I*

SHOWING METHOD OF USING A SYMBOL TO INDICATE VARIATIONS IN THE CHARACTERISTICS OF A GENUS OF FORAMINIFERA. EXAMPLE SHOWN ILLUSTRATES USE FOR *Rotalia*

Digit of Symbol	First	Second	Third	Fourth	Fifth	Sixth	Seventh
Characteristic indicated by digits	Shape of the dorsal side	Shape of the ventral side	Shape of the peripherical margin	Character of the sutures on the dorsal side	Character of the sutures on the ventral side	Position of the aperture	Number of chambers in the last coil
Interpretation of figure in digit	1. Convex 2. Slightly convex 3. Flat	1. Convex 2. Slightly convex 3. Flat	1. Broad round 2. Narrow round 3. Sharp	1. Straight Radiate Flat 2. Straight Radiate Depressed 3. Straight Radiate Raised 4. Straight Oblique Flat 5. Straight Oblique Depressed 6. Straight Oblique Raised 7. Curved Flat 8. Curved Depressed 9. Curved Raised	1. Straight Flat 2. Straight Depressed 3. Straight Raised 4. Curved Flat 5. Curved Depressed 6. Curved Raised	1. Near the umbilicus 2. Halfway between umbilicus and peripherical margin 3. Near peripherical margin	Figure corresponding to the number of chambers in the last coil

* Example: A specimen with biconvex tests, peripherical margin sharp, sutures on the dorsal side straight oblique depressed, sutures on the ventral side straight depressed, aperture halfway between umbilicus and peripherical margin, six chambers in the last coil. Symbol: 1135226.

species only, as many as twenty sufficiently independent types could be distinguished, and it was found that almost every one of these types has its own range.

For microlithological correlation it was presumed by the writer that in certain areas, at least, there may be a correlative value, not only in the so-called "heavy minerals," but also in the fragments of primary rocks found in many sediments, and in some secondary or epigenetic minerals. It is reasonable to believe that in some cases these minerals may be confined to certain horizons because their formation is due to underground waters. In order to find out if this might be true as regards the formations studied, a complete record of every change in the lithology of the examined samples was kept, and then the records obtained for different wells were compared with each other.

CHARACTERISTICS OF THE UPPER ETCHEGOIN

On account of the fact that most of the companies do not start coring until the lower part of the Etchegoin formation is reached, the only material available for studying the upper part of the formation consisted of sixty core samples from two wells drilled in the Buena Vista and Sunset oil fields, and fifty samples collected from the outcrops in an arroyo near Muddy Creek in the San Emigdio Mountains, where an almost continuous section of the formations developed in this locality is exposed.

From an examination of such meager material only a few general and tentative conclusions could be drawn. Thus, in the first place it was evident that the upper part of the Etchegoin is very poor in organic remains of any kind. Although as many as twenty-four different species of formanifera belonging to six genera were found in the samples examined, in no one sample were there more than five specimens of the microfossils. Moreover, the fact that the foraminifera in this part of the column are very often broken, and in many cases occur inside of fragments of white shale, indicates that the beds of the upper Etchegoin may be considered as redeposited.

The fragments of the white shale, together with small pebbles of chert and epidosite, sometimes accompanied by biotite flakes, hornblende crystals, and particles of carbonaceous material, are ap-

parently characteristic microlithological constituents of the Upper Etchegoin.

It seems very probable that some of the associations of the foraminifera and some changes in the relative abundance of the lithological components just listed may give a certain basis for differentiating within the formation several zones, from 50 to 100 feet thick, which can be used as correlative measures. Further study is necessary in order to determine the lateral persistence of these zones.

CHARACTERISTICS OF THE LOWER ETCHEGOIN

The writer's study of the Lower Etchegoin was much more complete than that of the Upper, because it was possible to obtain a very large number of core samples from this part of the column. The Lower Etchegoin differs strikingly from the Upper by the presence of rather diverse and abundant faunas represented both by foraminifera and other micro-organisms.

The results obtained from a micropaleontological study of the Lower Etchegoin are presented in chart form (Fig. 1), which shows the range of each species of the foraminifera and other micro-organisms found in the examined samples and the relative abundance of the species in various parts of the column. This chart shows that, based on the ranges of different species, there may be obtained a correlation as close as 13 feet in certain instances. But, as the horizons to which various species are confined do not coincide with each other, we obtain still closer correlations by using the ranges of associations of species.

It should be stated, however, that such a close correlation is not practical. As the chart shows, most of the species within the greater part of the studied column are present only occasionally, and, consequently, cannot be considered as giving a reliable basis for correlation. In view of this fact it is safer to differentiate in the Lower Etchegoin only twelve zones, varying in thickness from 22 to 245 feet. These zones, marked on the chart by letters *A*, *B*, *C*, etc., are sufficiently distinguishable from each other and are rather persistent laterally, so that by identifying them the writer was able to correlate fifteen wells located in different parts of the Sunset-Midway oil region and the district east of it, representative of an area embracing over 200 square miles.

Concerning the lateral extension of the established micropaleontological zones, one interesting thing may be pointed out. Although there were but three wells from which the writer had rather com-

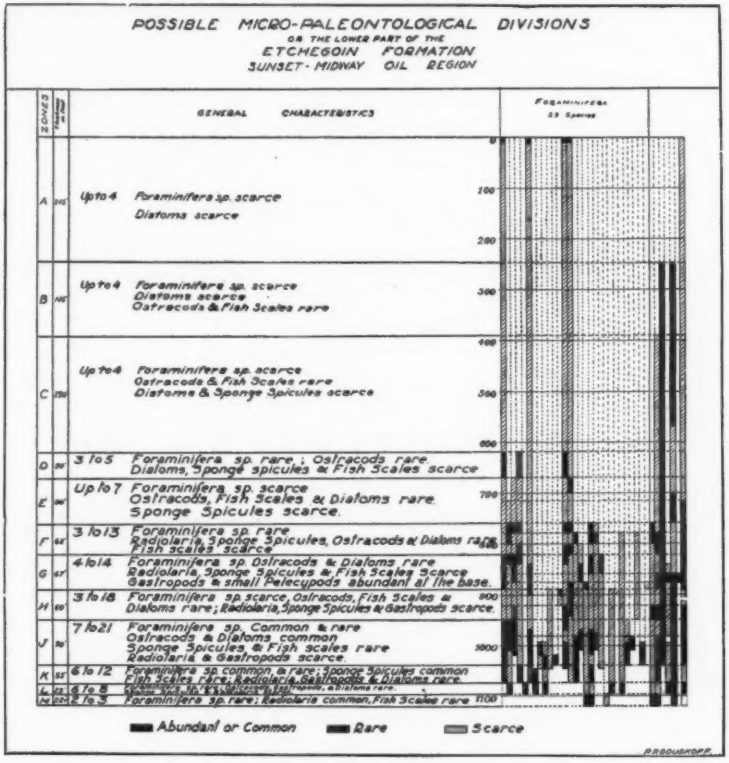
POSSIBLE MICRO-PALEONTOLOGICAL DIVISIONS
OF THE LOWER PART OF THE
ETCHEGOIN FORMATION
SUNSET-MIDWAY OIL REGION
ZONES
Thickness in Feet
GENERAL CHARACTERISTICS
FORAMINIFERA
A 245 Up to 4 Foraminifera sp. scarce
Diatoms scarce
100
200
B 145 Up to 4 Foraminifera sp. scarce
Diatoms scarce
Ostracods & Fish Scales rare
300
400
C 230 Up to 4 Foraminifera sp. scarce
Ostracods & Fish Scales rare
Diatoms & Sponge Spicules scarce
500
600
D 210 3 to 5 Foraminifera sp. rare; Ostracods rare
Diatoms, Sponge spicules & Fish Scales scarce
E 190 Up to 7 Foraminifera sp. scarce
Ostracods, Fish Scales & Diatoms rare.
Sponge Spicules scarce.
700
F 165 3 to 13 Foraminifera sp. rare
Radiolaria, Sponge Spicules, Ostracods & Diatoms rare
Fish scales scarce
G 137 4 to 14 Foraminifera sp. Ostracods & Diatoms rare
Radiolaria, Sponge Spicules & Fish Scales Scarce
Gastropods & small Pelecypods abundant at the base.
H 120 3 to 18 Foraminifera sp. scarce, Ostracods, Fish Scales & Diatoms rare; Radiolaria, Sponge Spicules & Gastropods scarce.
800
J 96 7 to 21 Foraminifera sp. Common & rare
Ostracods & Diatoms common
Sponge Spicules, & Fish scales rare
Radiolaria & Gastropods scarce.
900
1000
K 55 6 to 12 Foraminifera sp. common, & rare; Sponge Spicules common
Fish Scales rare, Radiolaria, Gastropods & Diatoms rare.
L 55 4 to 8 Foraminifera, Ostracods, Gastropods, & Diatoms rare.
M 200+ 2 to 3 Foraminifera sp. rare; Radiolaria common, Fish Scales rare
1100
Abundant or Common
Rare
Scarce
P.P. GOUDKOFF.

FIG. 1

plete collections of core samples, representing both the Upper and Lower Etchegoin, and the formation underlying the latter, it was found, with reasonable certainty, that in several wells some of the twelve zones are missing. Then a comparative study of the samples from these three, and another twelve, wells indicates that the farther east one goes from the coast range, the thicker is the Lower Etchegoin and the larger is the number of the described zones by which it

is represented. Some idea of such a relationship may be obtained from Figure 2, which shows a correlation of five wells and the surface section exposed in the arroyo near Muddy Creek. The column on the right side of this chart represents a well about 16 miles east of the coast range. The upper of the examined samples from this well falls somewhere into the *D* zone, but not into the middle of the *C*

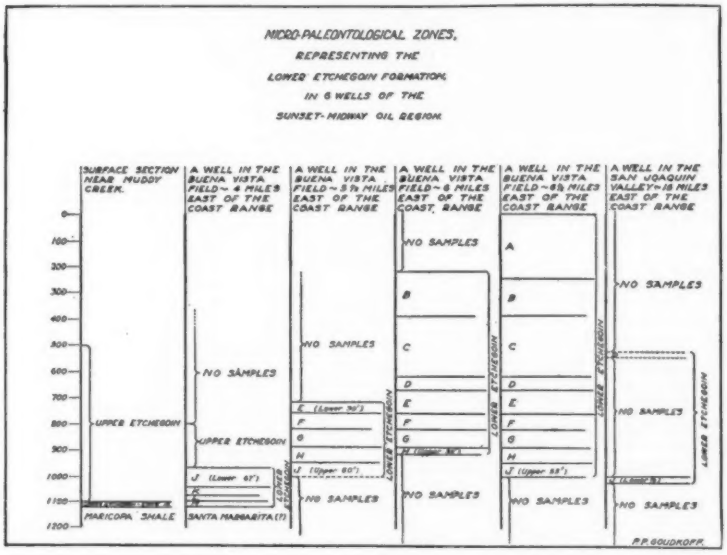
MICRO-PALEONTOLOGICAL ZONES,
REPRESENTING THE
LOWER ETCHEGOIN FORMATION
IN 6 WELLS OF THE
SUNSET-MIDWAY OIL REGION
SURFACE SECTION NEAR MUDDY CREEK.
A WELL IN THE BUENA VISTA FIELD ~ 4 MILES EAST OF THE COAST RANGE
A WELL IN THE BUENA VISTA FIELD ~ 5½ MILES EAST OF THE COAST RANGE
A WELL IN THE BUENA VISTA FIELD ~ 6 MILES EAST OF THE COAST RANGE
A WELL IN THE BUENA VISTA FIELD ~ 6½ MILES EAST OF THE COAST RANGE
A WELL IN THE SAN JOAQUIN VALLEY ~ 16 MILES EAST OF THE COAST RANGE
NO SAMPLES
UPPER ETCHEGOIN
MARICOPA SHALE
SANTA MARGARITA (?)
LOWER ETCHEGOIN
A
B
C
D
E
F
G
H
J
P.P. GOUDKOFF.

FIG. 2

zone, as one would expect, because of its vertical position above the lowest sample obtained from the same well. In other words, this well shows that in addition to the fact that the Lower Etchegoin as a whole thickens toward the center of San Joaquin Valley, some individual zones also increase their thickness in the same direction.

A general increase in the thickness of any formation toward the middle of a basin of deposition is, of course, not at all strange. But the absence of certain zones of the Lower Etchegoin in different parts of the region under discussion cannot be explained, in the writer's opinion, except by an unconformity separating the Lower

Etchegoin from its upper part. As supporting evidence of the probability of such a theory it may be stated that out of twenty-four species found in the upper part of the formation, only five were distinguished among the species found in the lower part.

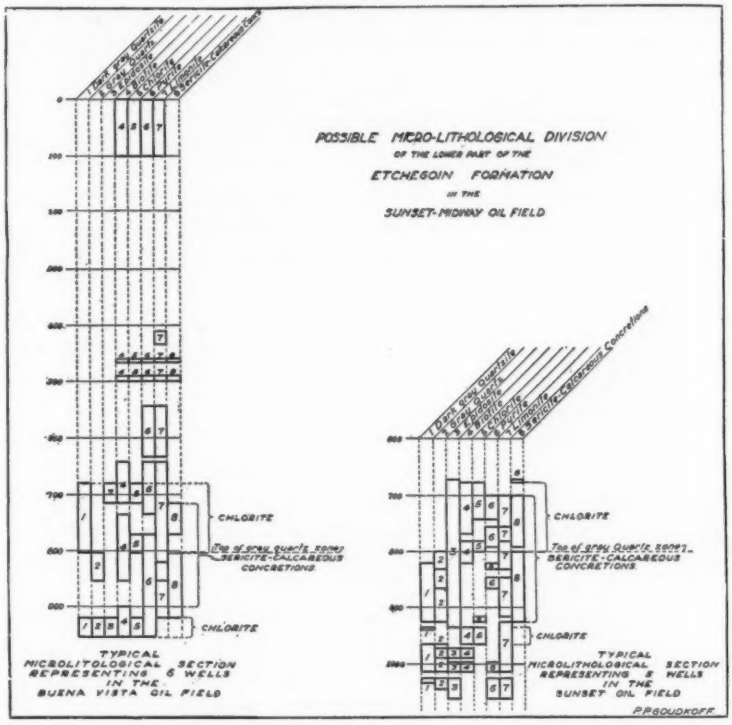

FIG. 3

The results of an analysis of the Lower Etchegoin from a microlithological standpoint are shown on the chart (Fig. 3), where the left column represents a typical section of six wells in Buena Vista, and that on the right side gives typical microlithological characteristics of a section representing five wells in the Sunset oil field. The columns are put one against the other on the basis of correlation by the foraminifera.

From a comparison of the two columns the conclusion may be drawn that out of eight recorded microlithological components only three—chlorite, sericite-calcareous concretions, and gray quartz—may be considered as having correlative value, because the horizons in which these components occur are within 25 feet of the same thickness and occupy the same stratigraphic position in both columns.

FORMATIONS UNDERLYING THE ETCHEGOIN

From the formations beneath the Etchegoin only about 150 samples were obtained, 100 being secured from a well in Buena Vista, seven wells in the Sunset field, and two wells in Wheeler Ridge, and 50 samples collected from the surface section near Muddy Creek. The writer's conclusions, from an examination of these samples, is summarized in Figure 4.

In the wells in the Sunset-Midway region, located at a distance 4 or 5 miles east of the coast range, we find, just below the Etchegoin, a formation mostly represented by gray or brownish-gray sandy shale. In the microlithological composition of this shale, and also in that of the streaks of sand interbedded in it, small fragments of dark quartzite, gray quartz grains, biotite flakes, and particles of carbonaceous material seem to be the most constant components. In some horizons these components are accompanied by rather abundant small pebbles of amphibolite and other metamorphic rocks.

The organic remains in this formation are represented by scattered diatoms and some arenaceous forms of the foraminifera closely resembling those found by the writer in several samples taken from the Santa Margarita shales exposed in the Kreyenhagen Hills and Pyramid Hills, and also from some shallow wells drilled between the Pyramid Hills and the southeastern end of the Kettleman Hills.

In parts of the Sunset-Midway oil region, adjacent to the coast range, as shown by samples obtained from some wells drilled in this locality, the Etchegoin is underlain by rather soft shales, lithologically similar to the shales just described. These also carry diatoms, but are apparently barren of foraminifera, and belong, in the writer's opinion, to the upper division of the Maricopa shale.

The formation represented by the deepest samples obtained by the writer may, in a general way, be classified as compact brown shale. Biotite and chlorite are the minerals commonly found in washed material of all the samples obtained from this shale.

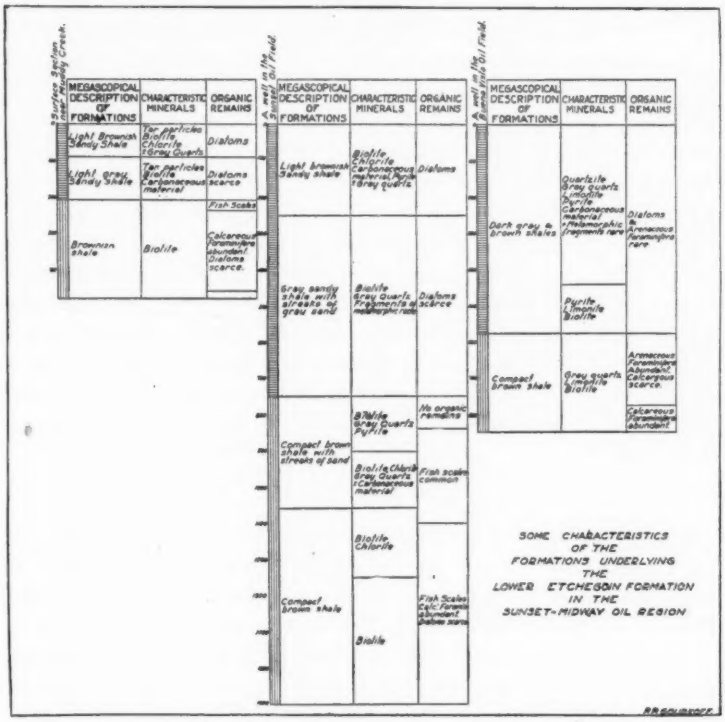
Surface Section near Sandy Creek.
A well in the Sunset Oil Field
A well in the Midway Field
MEGASCOPICAL DESCRIPTION OF FORMATIONS
CHARACTERISTIC MINERALS
ORGANIC REMAINS
Light Brownish Sandy Shale
Tar particles Biotite Chlorite Glassy Quartz
Diatoms
Light gray Sandy Shale
Tar particles Biotite Carbonaceous material
Diatoms scarce
Fish Scales
Brownish shale
Biotite
Calcareous Foraminifera abundant Diatoms scarce.
Light brownish Sandy shale
Biotite Chlorite Carbonaceous material Pyrite Glassy quartz
Diatoms
Gray sandy shale with streaks of gray sand
Biotite Gray Quartz Fragments of metamorphic rocks
Diatoms scarce
Biotite Gray Quartz Pyrite
No organic remains
Compact brown shale with streaks of sand
Biotite Chlorite Gray Quartz Carbonaceous material
Fish scales common
Biotite Chlorite
Compact brown shale
Fish Scales Calc. Foram. abundant Diatoms scarce
Biotite
Dark gray to brown shales
Quartzite Gray quartz Limonite Pyrite Carbonaceous material Metamorphic fragments rare
Diatoms & Arenaceous Foraminifera rare
Pyrite Limonite Biotite
Compact brown shale
Gray quartz Limonite Biotite
Arenaceous Foraminifera Abundant Calcareous scarce.
Calcareous Foraminifera abundant
SOME CHARACTERISTICS OF THE FORMATIONS UNDERLYING THE LOWER ETCHEGOIN FORMATION IN THE SUNSET-MIDWAY OIL REGION
RR SOUDSOFF

FIG. 4

The micropaleontology of the upper part of this brown shale does not seem to be quite persistent, the organic remains being represented in some wells only by fish scales; in other wells, by an association of arenaceous and calcareous foraminifera. In the lower portion, however, we find a very distinct zone characterized by a rather abundant fauna of the calcareous foraminifera. This zone is rather

persistent, as it was distinguished in six wells drilled in the Sunset field and in two wells in Wheeler Ridge. It may be of interest to mention that to this zone, in the writer's opinion, the oil sand discovered by the Obispo Oil Company well No. 6 in the thirty-five anticline is confined, the top of the sand being about 110–65 feet below the top of the zone carrying the calcareous foraminifera.

It is very likely that this zone should be correlated with the lowest part of the Maricopa shale as exposed in the section in the arroyo near Muddy Creek. But it must be mentioned that in the samples collected from this part of the section, beside the three species found in the core samples from the Sunset oil-field wells, about ten other species have been distinguished. A possible explanation of this difference may be that the core samples of the shale could not be broken down, and, consequently, the foraminifera had to be examined in the cores. Then, an examination of the surface section has shown that the foraminifera are not distributed throughout the thickness of the zone under discussion, and, as the writer had not a continuous set of cores from any of the wells, some of the layers sampled from the surface section might not have been represented in the core samples.

KERN RIVER SERIES

Concerning formations on the eastern side of the San Joaquin Valley, knowledge of the writer is restricted to results obtained from work in a district north of Bakersfield correlating the formations penetrated by two wells of this district with the oil measures of the Kern River oil field. One of the wells furnished samples ranging from a depth of 260 feet to 734 feet; the other furnished nineteen samples from between 1,260 feet and 1,540 feet. To correlate these well cores, a series of samples were also collected from the lower 370 feet of the Kern River series as exposed near Poso Creek on the road between the Kern River oil field and Woody.

A microscopical examination of this material has shown that (1) no organic remains are present in any of the formations represented by the collected samples; (2) the sampled part of the Kern River series and the formations penetrated by one of the wells to a depth of 734 feet show similar lithological compositions, which are char-

acterized by the presence of rather abundant crystals of dark, greenish-brown basaltic hornblende; (3) the formations penetrated by the other well, from 1,260 feet to 1,447 feet, differ distinctly in their lithology from the lower part of the Kern River series, being largely made up of quartz grains, small chert pebbles, and crystalline pyrite concretions; (4) the formation encountered by the same well below 1,447 feet may be distinguished from the formation just above this depth by the presence of small fragments of mica-chlorite schists, the relative abundance of which increases distinctly in a downward direction.

On the basis of such observations, the writer reported that the first well was still in the Kern River series, and that the other had not only entered the underlying Miocene, but was apparently approaching the contact of the Miocene with the metamorphic schists of Sierra Nevada. Later developments proved the writer's conclusions correct, as the second well shortly afterward entered the metamorphic schists.

SUMMARY

The results obtained from the writer's study of the oil-bearing formations in the Sunset-Midway oil region and in the district north of Bakersfield may be summarized as follows:

1. In the Upper Etchegoin several zones, from 50 to 100 feet thick, may be distinguished, differing from each other both in characteristic associations of twenty-four species of foraminifera and also in the relative abundance of three constant and three occasionally present microlithological components.

2. The best basis for the correlation of beds of the Lower Etchegoin is furnished by the associations of twenty-nine species of foraminifera, as shown by Figure 1, on the basis of which twelve distinctly different zones from 23 to 245 feet thick may be distinguished. Among the lithological components of the Lower Etchegoin only chlorite, sericite-calcareous concretions, and gray quartz, which are confined to some zones ranging in thickness from 50 to 220 feet, prove to be of correlative value.

3. In using the twelve micropaleontological zones of the Lower Etchegoin for correlation of wells in, and east of, the Sunset oil

district, it must be noted that all the zones are not always represented in the column. This fact leads to the presumption of an unconformity separating the lower part of the Etchegoin from the upper.

4. In that part of the Sunset district 4 or 5 miles east of the coast range the Etchegoin is underlain by a formation probably belonging to the Santa Margarita formation, which carries scattered diatoms and some arenaceous types of foraminifera. In that part of the same district, nearer the coast range, there is found, under the Lower Etchegoin strata, shale lithologically similar to that of the other parts of the district, but barren of the foraminifera and presumably representing the Upper Maricopa shale. In the writer's opinion, only variations in relative abundance of the foraminifera and in the associations of microlithological components may give a basis for correlation of the beds of these formations.

5. The deepest formation reached by the wells from which the examined samples were obtained belongs to the Lower Maricopa shale. Within this formation one very distinct and persistent zone characterized by abundant calcareous foraminifera has been distinguished. Also, the top of a zone to which rather common fish scales are confined may be used as a marker for correlating wells which have reached the Lower Maricopa shale.

6. Among the formations developed in the eastern side of San Joaquin Valley, the lower part of the Kern River series may be distinguished easily from the underlying Miocene by the presence of basaltic hornblende, which is absent in the Miocene beds.

THE WHEELER RIDGE OIL FIELD

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ABSTRACT

This paper treats of the location and economic importance of the field. The formations described are of Miocene and Pliocene age. The Wheeler Ridge anticline is an asymmetric fold, the north flank having the steeper dips. The structure is closed, the highest part of the structure being in the present developed area. There is a large fault south of the anticline which is not considered to be of the low angle, thrust type, but nearly vertical. Oil is recovered from sands in the Maricopa shale as well as from the Etchegoin formation.

The Wheeler Ridge oil field is located in T. 11 N., R. 20 W. in the extreme southern part of the San Joaquin Valley, Kern County, California. The present developed area is near the crest of an anticlinal ridge, the top of which is about 1,500 feet above the floor of the valley.

This paper is based on field work in the south side of the San Joaquin Valley carried on by two parties in 1923, consisting of W. A. English and W. P. Winham and G. M. Cunningham and T. B. Romine. The latter party covered the area included in the accompanying map (Fig. 1).

The discovery well in this field was completed at about 2,000 feet by the Standard Oil Company in 1922. The same company had previously drilled a dry hole on the axis of the fold about a mile and a half to the east. More recently several wells have been completed from sands at least 2,000 below the upper productive zone.

The development of the Wheeler Ridge field has been carried on slowly, and at the present time the productive area is confined to the north half of Section 28. Production from eleven wells amounted to about 1,000 barrels of oil per day in June, 1924. In September, 1925, twenty wells produced an average of 874 barrels of oil per day.

STRATIGRAPHY

The stratigraphy of the south side of the San Joaquin Valley has been discussed in detail by R. W. Pack.[1] All the formations, with

[1] R. W. Pack, "The Sunset-Midway Oil Field," *U.S. Geol. Survey, Prof. Paper* 116.

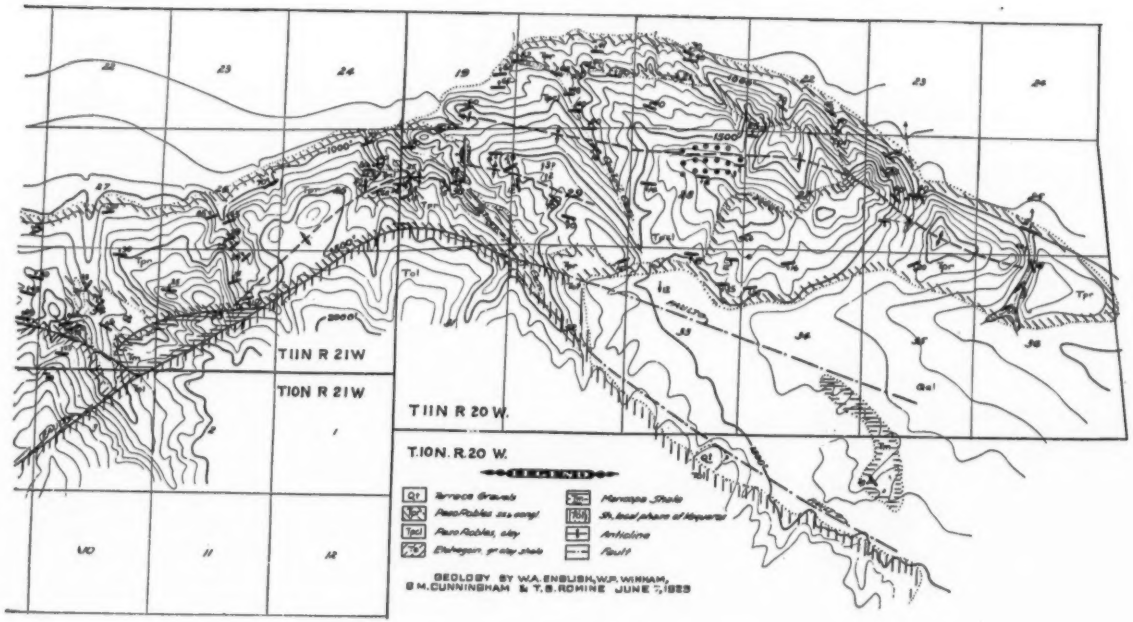

FIG. 1.—Geologic map of Wheeler Ridge anticline

the exception of the Quaternary gravels and the Paso Robles formation of Pliocene age, are of marine origin. The following brief descriptions are intended to apply only to the immediate vicinity of Wheeler Ridge.

QUATERNARY

Terrace gravels.—Terrace gravels are present throughout the hilly areas west of Wheeler Ridge. One large deposit is located about a mile and a half from the mouth of Pleito Creek Canyon. Larger deposits of bench gravels are present near the mouth of San Emigdio Canyon to the west. The gravels consist of angular bowlders and coarse material derived from the crystalline rocks in the higher mountains to the south. Although easily confused with the upper part of the Paso Robles formation in this area, the terrace gravels are less strongly consolidated than the Paso Robles conglomerates, and are gray in color when viewed from a distance, lacking the yellowish tints present in exposures of the Paso Robles.

PLIOCENE

McKittrick group.—This group includes the Paso Robles and Etchegoin formations of Pliocene age. These two formations appear to be conformable, but the Etchegoin, throughout the south side of the valley, overlies the Miocene diatomaceous shales with marked unconformity.

The Paso Robles formation, particularly on the Wheeler Ridge anticline, is divisible into two members, neither of which is of marine origin. The upper member consists of buff-colored, coarse sandstones and conglomerates, with occasional beds of yellowish and gray sandy clay. This member very nearly encircles the structurally higher part of the Wheeler Ridge anticline. The lower member, exposed on the crest of the fold, consists of gray and buff-colored clays, thin sands, and conglomerates, and is easily distinguished from the upper, more conglomeratic member. A similar division of the Paso Robles formation into two members can be made on the Elk Hills and Buena Vista anticlines to the northwest of Wheeler Ridge. Sandy beds which are penetrated by wells on the crest of the fold to a depth of about 1,000 feet probably belong to the Paso Robles formation.

The most extensive exposures of the Etchegoin formation are

west of the immediate vicinity of Wheeler Ridge. The formation consists almost entirely of gray clays and sandy clays. Marine fossiliferous beds are found near the base of the formation. It is probable that the upper productive zone in the Wheeler Ridge field is in this formation.

Miocene

Santa Margarita formation.—No exposures of the Santa Margarita formation, which is composed mainly of sandstone, are present in the vicinity of Wheeler Ridge, although the formation has been noted about ten or twelve miles to the west and in the Comanche Point area on the east side of the San Joaquin Valley. A mile west of the western limit of the accompanying map the Etchegoin formation rests directly on the Maricopa shale, which sequence makes it seem probable that the Maricopa shale, which may or may not contain beds of Santa Margarita age, is the youngest Miocene formation present beneath the Wheeler Ridge anticline.

Maricopa shale.—The name "Maricopa shale" is applied by Pack to a thick formation of diatomaceous shale which is the local representative of the upper part of the Monterey group. The Maricopa shale is exposed in two faulted areas in the vicinity of Wheeler Ridge. One of these exposures lies about a mile and a half south of the axis of the Wheeler Ridge anticline, where it is completely surrounded by alluvium. Although its structural relation to the other formations is obscured, there is little doubt but that it is separated by a fault from the Paso Robles formation to the north.

Vaqueros formation.—Pack classified all beds occupying the stratigraphic position between the Maricopa shale and the Tejon (Eocene) formation as the Vaqueros formation. South of Wheeler Ridge our examination of these beds was confined to a narrow strip on the south side of a large fault. In that area the Vaqueros is almost entirely composed of dark gray to nearly black clay shale which weathers to a chocolate-colored soil. About ten miles west of Wheeler Ridge, exposures on the east side of San Emigdio Creek seem to indicate these shales to be well down toward the base of the Vaqueros. For this reason they have sometimes been referred to the Oligocene.

STRUCTURE

The Wheeler Ridge anticline.—The Wheeler Ridge anticline is an asymmetrical fold trending about N. 10° W. It is a closed structure whose high point is within, or slightly west of, the present developed area. Dips on the north side of the anticline are as steep as 70 to 80 degrees along the north edge of the hills. On the south flank the average dip is from 10 to 12 degrees for the first three-quarters of a mile south of the axis. Farther to the south the dip becomes as high as 25 degrees.

The axis of the fold has a marked plunge to the east from the producing area. In the western end of the ridge the anticline is less sharply folded.

The accompanying cross-section (Fig. 2), taken through the developed area, indicates the asymmetric character of the fold. Theoretically, in this type of folding, the plane of the axis of the fold should incline toward the direction of the flank of lesser dip. Such seems to be the condition in the Wheeler Ridge anticline, as the axis of the fold in the upper producing sands lies definitely to the south of the trace of the anticlinal axis on the surface.

Productive formations.—Wells drilled on the top of the structure pass through about 1,000 feet of sandy beds belonging to the lower part of the Paso Robles formation. Below this there is a thickness of 1,000 to 1,200 feet of beds of the Etchegoin formation, composed chiefly of clay and containing the upper producing sands practically at the base of the formation.

Below the Etchegoin formation the deeper wells penetrate more than 2,000 feet of hard brown and sandy brown shale representing Maricopa formation. The deepest producing sands are in this formation.

Faults.—A long strike fault with downthrow to the north lies south of Wheeler Ridge. This fault has commonly been reported as a low-angle fault thrust toward the north, but there seems to be little field evidence for this conclusion. The fault plain, where exposed, is nearly vertical and certainly does not dip at an angle less than 75 degrees to the south.

In the south half of Sec. 34, T. 11 N., R. 21 W., a combination of conditions has produced a very deceiving optical illusion suggestive

FIG. 2

of low-angle thrust faulting. At this locality the upper surface of the terrace gravels, with the Etchegoin shale exposed higher on the canyon wall, has been mistaken for the trace of a horizontal fault between the Etchegoin and Paso Robles formations. The effect is further emphasized by a peculiar coincidence. At this locality there is a very nearly vertical fault between the Paso Robles and the Maricopa shale immediately north. The trace of the fault is parallel to the topographic contours and, from the opposite side of the canyon, appears as the prolongation of the line formed by the upper limit of the terrace deposits. The illusion thus produced suggests low-angle thrust faulting of Etchegoin shale over Paso Robles conglomerates, which is certainly not representative of the actual conditions.

SUMMARY

There are several geological features of interest in connection with the field. The productive area is located on the crest of an anticline which is strongly reflected in the surface topography. The anticline is related to nearly vertical faulting in the area to the south. The axial plane of the structure is inclined to the south, due to the asymmetrical character of the fold. The oil occurs in the same field both in the lower beds of the Etchegoin formation and in sands in the Maricopa formation.

THE PLIOCENE AND PLEISTOCENE HISTORY OF THE BALDWIN HILLS, LOS ANGELES COUNTY, CALIFORNIA[1]

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ABSTRACT

Trenches near the Baldwin Hills (Inglewood Oil Field) exposed the best section of Pliocene-Pleistocene sediments known in the Los Angeles basin. A northeast-dipping series revealed (*a*) Upper Pliocene sands with a cold-water fauna; (*b*) hitherto unknown sands with a warm-water fauna; (*c*) "Lower San Pedro" sands with a cold-water fauna; (*d*) "Upper San Pedro" gravels and sands with a warm-water fauna; (*e*) freshwater sands and clays, carrying *Mylodon*, presumably the same species as is found at Rancho La Brea. Overlying all these beds was an unconformable bowlder bed of river origin. At this point a fault threw down beyond observation both the tilted series and the river bowlders. The bowlder bed may be very late Pleistocene. Overlying it, east of the fault, were peat-streaked sands—flood-plain or lagoonal deposits due to impounding. About halfway up in this material human remains were found. Their age is in doubt. Structurally, evidence exists that the Baldwin Hills is an uplift finally made in very late Pleistocene time, with a northwest-plunging nose.[1]

INTRODUCTION

In 1903 Dr. Ralph Arnold published his *Stratigraphy and Paleontology of San Pedro*. Very little has since been advanced on the Pliocene and Pleistocene of Los Angeles and its environs, though Arnold, and later, Moody, have contributed valuable lists of fossils. No one at all has written about the Baldwin Hills, at present in the limelight because of oil possibilities. It has been assumed that in these hills would be represented Arnold's geological trilogy—Upper Pliocene with a cold-water fauna, and Pleistocene, subdivided into "Lower San Pedro," with a fauna representative of waters colder than at present but warmer than in Pliocene time, and "Upper San Pedro," with a fauna from waters warmer than those of the present time. For the term "Lower San Pedro" formation, W. S. W. Kew has recently suggested, in work for the *U. S. Geological Survey*, the name San Pedro formation, and for the term "Upper San Pedro" forma-

[1] The date of this paper's reading was September, 1924. Further investigation, broken off in February, 1925, has inclined the writer to the belief that the bowlder bed is of markedly recent historical time. Accordingly, the human remains would lose any significance as evidence of man in California numerous thousands of years ago.

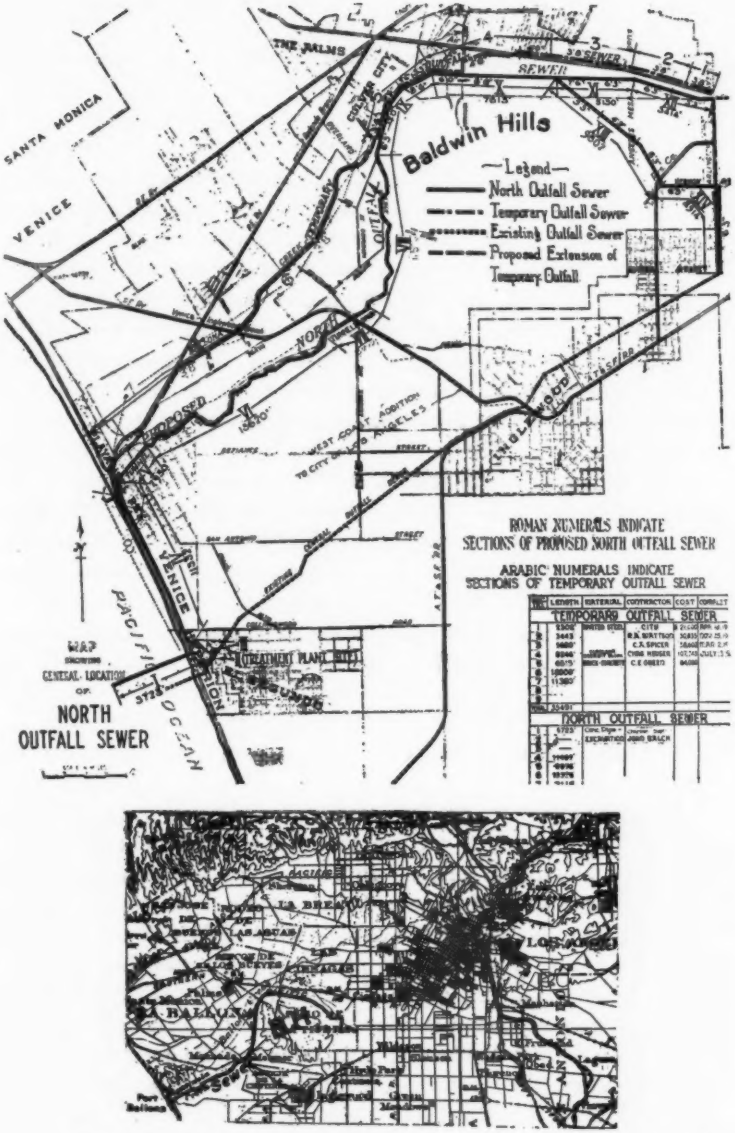

FIG. 1.—Map showing location of the North Outfall sewer, west of Los Angeles, California. The small map shows relation to surroundings, but the city now covers very much more of the area than here indicated.

tion, the name Palos Verdes formation. These new names will be used throughout this paper.

TOPOGRAPHY

The Baldwin Hills (Fig. 1), which lie just beyond the western limits of the city of Los Angeles, constitute a cuesta-like uplift rising rather abruptly from the coast line near Playa del Rey and ascending gently northeastward to a maximum elevation of 402 feet. On the southeast, and to some extent on the east, the Hills slope downward gradually, but on the northeast and northwest they present sharp, almost clifflike faces, except where these are masked by fans from numerous ravines. Abutting these northeast and northwest fronts is that portion of the Los Angeles basin which is here styled Ballona plain, because of Ballona Creek, a feeble stream which meanders across the plain to the sea. On the northeast, at the junction of Western Avenue and St. Andrews Place, Ballona plain gives place abruptly to a 200-foot escarpment. This escarpment, which is really a system of masked terraces, strikes northeast through Los Angeles to the Elysian Park Hills. It also extends northwest, and then south-southeast, in a somewhat irregular and broken semicircle to the sea near the southeastern limits of Ocean Park.

OPPORTUNITIES FOR GEOLOGIC INVESTIGATION

The Baldwin Hills have, of course, not been uninvestigated as to stratigraphy and structure, especially by petroleum geologists. But in the Hills exposures are few, scattered, and poor, and until 1924 Ballona plain presented nothing to the investigator except an unpromising alluviated surface. In 1924, however, the city of Los Angeles dug a series of trenches for the laying of the North Outfall sewer. These trenches are located on all sides of the Baldwin Hills, in places slicing the hill slopes perpendicularly, in others cutting across Ballona plain to a depth of over 20 feet (Fig. 1). The excavations ran from Hyperion to Playa del Rey on the southeast front, from Playa del Rey to Centinela Boulevard on the northwest front, from Centinela Boulevard to Culver City on the west front, from Culver City to Angeles Mesa Drive on the north and northeast fronts, and from Angeles Mesa Drive to Slauson and Van Ness

avenues on the east front. The trenches were numbered by sections from 1 to 14. Quite unexpectedly they revealed a far more complete Pliocene-Pleistocene section than any hitherto known or even postulated. It is the contribution of these trenches to the history not only of Baldwin Hills but of the Los Angeles basin that will now be considered.

DESCRIPTION OF ROCK FORMATIONS

For stratigraphic and paleontologic, and even for structural, purposes interest will be centered on the division of the sewer known as Section 10, extending eastward through Ballona plain along the northeast front of the Hills, and on its continuation known as Section 11. In Trench 10, as soon as the alluvium is passed through, there appears a great bowlder bed at an average depth of 3 feet below the surface—a bowlder bed which extends eastward for nearly a mile, until it is cut off by a fault. This horizontally lying bed, as will be seen, reveals a new chapter in the history of what will here be called the Ur–Los Angeles River (Ur meaning primitive).

Beneath the bowlder bed lies the real discovery—a series of tilted strata dipping N. 35° E. at an angle of approximately 15°. Since the trench cuts across these tilted strata almost at right angles to the dip, the sequence was beautifully exposed as day by day the excavation progressed. The sequence is as follows:

SECTION AS EXPOSED IN TRENCH 10 OF THE LOS ANGELES OUTFALL SEWER

	Feet
Loam	1– 3
Peat and clayey sands	2–32
INDEFINITE UNCONFORMITY	
Bowlders, unconsolidated river material	1–20
UNCONFORMITY	
Bluish fresh-water clays (5) alternating with micaceous sands and rarer gravels. Blue clay No. 2 with ground-sloth remains	300
Unfossiliferous sands	150
Palos Verdes sands, fossiliferous	50
Unfossiliferous sands of beach type	104
FAUNAL UNCONFORMITY	
San Pedro sands, fossiliferous	100
FAUNAL UNCONFORMITY	
Grits, fossiliferous, and laterally variant to gravels	1– 4

	Feet
Sands, unfossiliferous, of beach type	0?–25
Sands, fossiliferous	0?–25
UNCONFORMITY	
Upper Pliocene sands, markedly clayey, fossiliferous	223

An approximately correct thickness for the tilted Pleistocene strata alone is thus seen to be between 700 and 800 feet. Arnold's figure, derived from a study of Deadman Island, off San Pedro, and of the adjacent shores is startlingly different—100 feet more or less. The new information, however, checks well with the occurrence of a Palos Verdes fauna formed 660 feet below the surface in a water well near the Bandini tract of Los Angeles and with Arnold's mention of Palos Verdes fossils as found near Bell at a depth of 920 to 1,320 feet. As will appear later, the Trench 10 sequence probably does not reveal all the Pleistocene of Los Angeles.

The chief characteristics of the Upper Pliocene material are its remarkable homogeneity and its clayey-sandy nature. Doubtless, as is testified by numerous oil wells about Los Angeles, it maintains this homogeneity to a much greater thickness than the 223 feet examined. Further, the beds were deceptively massive on first glance, though really composed of thin, contorted laminae. Gray in color and clearly consisting of fine-grained quartz with much-comminuted mica when dry, the sands resembled, when wet, a tenaciously cohesive clay of bluish aspect. Possibly sandy shale should be the name applied to them in order best to assist the imagination of the reader. The fauna consists of fifty-three species of invertebrates, chiefly pelecypods and gastropods of notably cold-water facies, some forms indeed being now limited to circumboreal waters. All lines of study point to the age of the strata as Upper Pliocene—though it may be remarked in passing that there might be some advantages in referring the entire Upper Pliocene marine faunas investigated by Arnold, Dall, Moody, and the present writer to the initial stages of the Pleistocene. For the purposes of the petroleum geologist the point is not important, however; the horizon is a clearly defined one.[1]

[1] Complete information as to results of mineralogic and paleontologic study of these and all other beds, with lists of fauna, will be published in a monograph of the Los Angeles Museum, under whose auspices the study here briefly outlined was carried on for many months. A second set of trenches going north from Culver City to Hollywood is now under observation; it should throw light upon the age of the famous Rancho la Brea fauna.

At Deadman Island the San Pedro formation lies directly, though unconformably in dip and strike, upon the Upper Pliocene. In Trench 10 and, as the writer now knows, elsewhere, the Upper Pliocene is separated from the San Pedro horizon with its cold-water fauna by a series of coarse beds whose dip and strike indeed are those of the Pliocene, but which intermesh very irregularly into the Pliocene clayey sands and which carry a sparse fauna of distinctly warm-water aspect. To those who may have casually seen these beds it should be stated that, although these coarse sands, where their gravelly facies were directly unconformable beneath the river gravels above, could be easily mistaken for the river gravels proper, close examination revealed differing types of bowlders, the presence of moonstones, and certain variances in cross-bedding. All of these, apart from the fauna, proved that they were *not* the upper river gravels.

If the so-called "Upper Pliocene" marine strata were correlated with the lowest Pleistocene, would the warm-water strata then be interglacial? The time is certainly not yet ripe for any correlation between the recognized East–United States glacial formation series and the Pleistocene strata of California.

Clearly unconformable above the pebbly beds which close this warm-water series are the clayey sands of the San Pedro formation. Very abruptly and with marked vertical irregularity the warm-water gravels give place to fine sands scarcely distinguishable, except perhaps as to color, from the Upper Pliocene. The sands are somewhat more of a brown than a gray color when dry. They do not greatly resemble the "Lower" San Pedro "fine gray" sands of Deadman Island, but, in general, a lithological macroscopic similarity or dissimilarity means relatively little in the description of southern California formations. The fauna, of which some thirty species have thus far been identified, is best considered as of San Pedro age.

In the section described an unconformity has been indicated directly above the fine clayey sands of the San Pedro formation. This unconformity was inferred because of the abrupt change from the fine material to coarse, cross-bedded sands, largely quartzose, but without large pebbles such as characterize the river gravels truncating these sands. In these sands cross-bedding is present on a large scale, sweeps of 20 feet horizontally and 5 feet vertically being

common. Unfortunately, the sands are unfossiliferous, though undoubtedly marine.

The Palos Verdes sands (and perhaps it is just below these that the unconformity should be placed) offer no particular problem. They are massive, gray-green, very coarse to gravelly, quartzose and loosely cemented, and contain pebbles up to one-half inch in diameter. Sand dollars (*Echinarachnius excentricus* Esch.?) are amazingly abundant, and the pelecypods and gastropods are typically Palos Verdes, with some seventy species thus far identified. There are several variations of coarse- to medium-grained sands.

New to the Pleistocene section, and thus again of greater interest, are the fresh-water beds which overlie the Palos Verdes strata. These consist of alternations of bluish clays with sands, massive, gray-green, pebbly, micaceous, and, unfortunately, unfossiliferous. The blue clays are dense, massive to laminated, chunky at times, and extraordinarily cohesive when wet. Since the presence of *Lymnaea*, *Planorbis*, *Anodonta*, and the bones of a ground sloth clearly indicate the fresh-water origin of the clays, it is assumed that the sands are also fresh-water.

At this point the fault mentioned above interrupts the tilted series. Before the consideration of the resulting hiatus it will be well to try to formulate the history of the Baldwin Hills, as the beds seem to reveal it.

GEOLOGIC HISTORY

There is a growing tendency to interpret the history of small, even very small, areas in southern California as structural units in themselves during ever constant crustal movements. Disconcerting as this procedure may be to those who like simplicity both in stratigraphy and structure, the Baldwin Hills seem to have been such an unneighborly block to other elevations in the vicinity.

This much is certain during Miocene time. Neither the Hills proper nor Ballona plain throw any light upon whether the Hills participated in various movements upward supposed, and even in some cases proved, to have been shared in by such neighbors as San Pedro Hill. In any case, Pliocene time saw only an expanse of rather deep and quiet waters covering what is now the hills and plain, the terraced elevations northeast and west of the plain, etc.

The great thickness of the homogeneous Upper Pliocene sands, the large admixture of clay, the fineness and evenness of the rounded quartz fragments, the comminution of the mica, the thinness of the laminae, the quite perfect preservation of very delicate shells—all point to a currentless arm of the sea, presumably with low shores. If these shores were bounded on the north by the Santa Monica Mountains, then the latter were probably far lower than at present. The climate—or at least the temperature of the waters—was cold.

The sharp tilt observable in the Pliocene beds, however much it suggests an elongated anticline or a dome, did not necessarily follow on the heels of Pliocene deposition. There would seem to have been some emergence. There is evidence in the shattered condition of the fossils of the coarse sands and gravels above the Pliocene that there was marked and sudden shallowing of the regional waters; bowlders of quartzite range up to 6 inches in diameter. With the shallowing the cold-water fauna largely fled—though it is doubtful if the shallowing without climatic change could have effected the faunal revolution to which the invertebrates bear testimony. Without further evidence as to where the fine material which would have been eroded from the Pliocene went to, the amount of uplift is uncertain.[1]

The time of the warm-water fauna, however, was not short, as men compute time. And again there followed rather profound submergence, bringing back the cold-water fauna; presumably a cold climate accompanied the change, though one more moderate than in Upper Pliocene time.

Arnold postulates renewed uplift of somewhat indefinite type, with rapidly alternating subaqueous and beach conditions at the close of San Pedro time. The writer believes that there is even less likelihood that the Baldwin Hills were markedly elevated at this time than at the close of the Pliocene.

With the progress of the alternations came Palos Verdes time. It is noteworthy that the marine Palos Verdes strata, as Arnold himself suggested, are not the latest Pleistocene record in Trench 10.

[1] On the northeast flank of Baldwin Hills there are beds which probably were deposited above the Pliocene of the trenches and below the warm-water strata. Their presence emphasizes the time-gap in the trench, but does not solve the problem of uplift. Sufficient study has not been given these beds to permit definite statements about them.

Certainly, as the blue clays show, long after the region where the Palos Verdes shells had flourished had become land, the ground sloth was roaming the vicinity of Los Angeles. The period of deposition represented by the blue-clay beds may be also the time of the trapping of the La Brea fauna a short distance to the north. Up to the present there is no direct evidence of this possibility.

The alternating blue-clay and gravel beds, however, of Trench 10, may be correlated with a series of marine gravels which carry a fauna of still more warm-water aspect than that of the Palos Verdes strata, and which may be tentatively styled the Centinela gravels, since they were exposed south of Centinela Creek, in Trench 6. On the other hand, these Centinela gravels may represent a new submergence of the Baldwin Hills region. To return to Trench 10, the observations are as follows:

A cross-fault occurs just where the fifth-stratum blue clay unconformably underlies the horizontal bowlder bed previously mentioned, striking approximately N. 30° W., and throwing down on the eastern side of the fault plane not only the tilted series, but the bowlder bed itself to a depth of some 30 feet. Observations were, of course, effectively interrupted, except in so far as material above the bowlder bed was concerned.

Trenches 9, 8, 7, 6, and 5, on the northwest flank of the Baldwin Hills and presumably on the southwest limb of the anticline which the northeast dips in Trench 10 *may* indicate, might have been expected to repeat the Pliocene-Pleistocene sequence. The Pliocene appeared in Trench 9, dipping southwest. Unfortunately, the dip was very gentle, so that, whereas on the northeast the bowlder bed had been laid down across a sharply tilted and truncated series of strata, on the southwest the river had removed all the younger beds completely. Only where the banks of the ancient river were revealed could the desired sequence be followed.

With many hiatuses, due to the fact that the trenches in many places cut only the ever deepening alluvium of Ballona plain, portions of the sequence were picked up. It is also believed that something like 70 feet of strata, largely marine sands and gravels, really lies stratigraphically above the youngest blue clay of Trench 10. In any event, it seems clear that the true deformation of the Baldwin Hills region took place only after post-Palos Verdes time.

The remaining history of Ballona plain may be here rather briefly dismissed. As may be seen from the vertical section of Trench 10, above the bowlder bed (east, however, of the cross-fault) lie peat and clayey sands. This material, containing fresh-water gastropods of marsh-loving proclivities, indicates that the river eventually languished and died. It may be that the river finally cut through a structural barrier of which there is now no surficial evidence but which once ran east from the Baldwin Hills. It thus came to approximate the present channel of Los Angeles River. It may be that the river merely built up a fan and finally flowed down the other side. It seems, however, probable that the cross-fault just mentioned diverted the course of the river and the former flood plain became a tule bog; at least it is significant that west of the cross-fault there is very little peaty material, that just east of the cross-fault 32 feet of nearly pure peat caused great distress to the contractors, and that farther east the 20 feet or so observable gives the following curiously constant series:

Loam
Sand
Carbonaceous earth
Sand
Carbonaceous earth
Sand
Carbonaceous earth
Sand, very clayey

Even the thickness of the various members of this series does not vary markedly. At one point, at a depth of 19 to 23 feet, and below the third band of carbonaceous earth, were exhumed the remains of six human skeletons. Of the discovery much sensational newspaper nonsense has been made. The skeletons may be unusually old; they may be comparatively recent. That is all to be said at present.

STRUCTURE

Is the Baldwin Hills uplift an anticline, a dome, or merely a terrace? The dips examined swing slowly around from southwest to northwest to northeast in a manner rather pleasing to the petroleum geologist. A plunging anticline is suggested. But there are observations which do not fit in well with an anticlinal hypothesis. The oft-

mentioned bowlder bed, unconformably overlying the tilted Pleistocene strata of Trench 10, is that deposited by a river. The bowlders are subangular, ill-sized, ill-sorted, and confusedly piled. Vertically and laterally bowlders give place to sands and gravels in inextricable confusion. Cross-bedding on a large scale is common. The character of this material—largely coarse granite bowlders ranging up to 18 inches in diameter—and its disposition closely resemble that of the fan of the present San Gabriel River. This ancient river was also a large one, for tree trunks as much as 3 feet in diameter and 12 to 30 feet long were carried down its course. It had tributaries, one in particular bringing chlorite schist from the Santa Monica Mountains, as revealed in Trench 9. It seems to have been a Pleistocene river: in its reaches were found the tooth of a mastodon, and the vertebra of a saber-tooth.

The most significant fact, however, about this river, here called the Ancient Los Angeles River, is that its terraces can be traced. It seemingly had a course extending from the present Arroyo Seco through the city of Los Angeles and out between the Baldwin Hills and West Adams Street Hill, debouching south of Culver City. The highest terraces are almost certainly on the level of the summit of the present Baldwin Hills. It is difficult not to believe that when the Hills were slowly elevated there was no Ballona plain, but merely a low foreland crossed by this river and backed by the Santa Monica Mountains. In process of time faulting began—faulting which eventually resulted in marked depression of Ballona plain and marked relative elevation of the Baldwin Hills. The faulting on the northeast front steepened the dips.

The above suggestions may not be borne out by the writer's studies now being continued. But at least it will be well for the petroleum geologist to study for himself the course and history of this river, so unexpectedly discovered; incidentally, to note all the dips in the Hills proper, and not merely a few seemingly pleasing ones.

CORE DRILLING FOR STRUCTURE IN THE NORTH MID-CONTINENT AREA[1]

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ABSTRACT

Application.—Principally used in Permian outcrops of northwest Oklahoma and southern Kansas.

History and development.—Description of first equipment used. Success attendant early use caused adoption by many large operators. More than thirty-five drills now being operated in Oklahoma and Kansas. Present equipment fairly well standardized. Deeper drilling will necessitate heavier machines. Gasoline motor-driven drill, the use of mud fluid, and application of hard alloys on fishtail bit surfaces principal developments of 1925. The use of separate pumps for hydraulics will probably soon be adopted.

Methods of operation.—Organization: Description of organization and how it functions as a part of the geological department. Types of equipment used: Some operators prefer steam drills. Majority prefer gasoline-driven drills mounted on wheels. Portability a desirable feature. Self-propelling drills being used successfully. All drills use N rods and cut 2-inch core. Use of mud eliminates use of casing. The amount of core recovered is reduced to a minimum consistent with conservative correlations. Fishtailing has reduced costs. Application of special alloys to fishtail bits has increased footage per bit two or three times.

Procedure.—Description of procedure in making a location, rigging up, drilling, etc., key beds, correlations, logs, elevations, and maps.

Costs.—Estimates of costs of equipment. Wages. Fuel. Repairs. Costs analyzed. Cost per month is most important and inflexible of all costs. Costs per foot of hole, or per acre, depend on the area in which drilling is done. Comparative costs hard to obtain.

Results obtained.—Productive structures found with the aid of core drill. Structures found with the core drill which are now being tested.

PART I

APPLICATION

The use of the core drill for determining structural conditions is finding its chief application in those areas of Oklahoma and Kansas where the surface outcrops are of such a nature as to prevent detailed mapping by the usual plane-table methods. These areas may be considered as largely coincident with the outcrops of the Wellington shale and later beds. There are certain areas in the Enid formation which can be detailed satisfactorily and the same, of course, is true of the Wellington; but the greater part of the areas of these rocks are not amenable to ordinary field methods and recourse has

[1] Paper presented at Annual Meeting of American Association of Petroleum Geologists at Dallas, Texas, March 26, 1926. Prepared with co-operation of all the companies using core drills.

been had to the use of the core drill. This area of Permian outcrops, where the core drills are being principally used, is about 100 miles wide, and extends from Guthrie, Oklahoma, north beyond McPhearson, Kansas. The regional dip of the rocks is to the west or southwest with an inclination of 20–40 feet per mile.

In this area it is usually possible to find key beds to establish reliable correlations at comparatively shallow depths. The western limit of operations is determined principally by the depth to which the drills can penetrate satisfactorily. At present holes deeper than 900 feet are the exception, and these depths are necessary in northwestern Oklahoma in Range 6 W.

There are other areas where the core drill is used to supplement existing information, but in no other part of the north mid-continent area are the structural conditions worked out so exclusively by the core drill.

HISTORY

Credit for the introduction of the diamond core drill into the mid-continent area for use in determining structural conditions belongs to Mr. M. M. Travis, formerly of the Midco Petroleum Company. While visiting some mines in Colorado during the summer of 1918 Mr. Travis saw a steam-driven core drill in operation and was impressed with its possibilities as an aid to structure finding in this part of the country. At his request the E. J. Longyear Company of Minneapolis designed a gasoline-driven diamond core drill, mounted on a steel frame and wheels. This machine was used early in 1919, checking up the structural conditions on two supposed folds mapped by the government on the Chilocco Indian Reservation in Kay County, Oklahoma. According to Mr. Travis, about twenty-five holes, ranging from 50 to 200 feet in depth, were drilled, which indicated that a mistake had been made in the surface mapping. Two or three holes a week were drilled with this machine. After this work some holes were put down around the Billings pool in T. 23 N., R. 2. W., Noble County, Oklahoma. So far as known this was the first application of the diamond core drill to structure finding in the north mid-continent area, and it is interesting to note that the first drill used was a portable gasoline-driven machine, and that we are today using drills which combined these features.

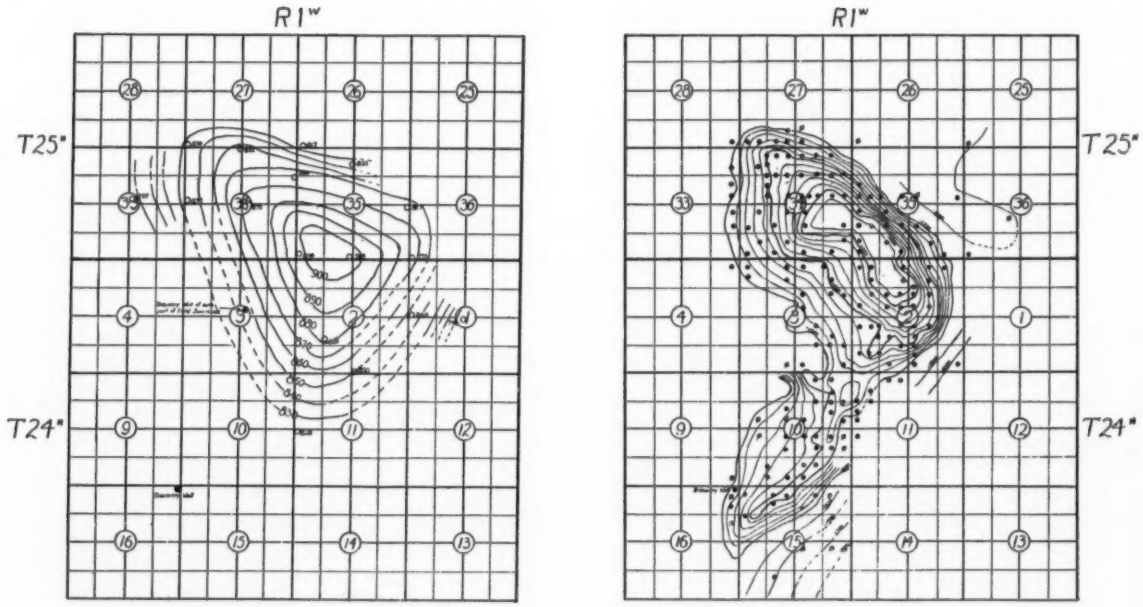
In October, 1921, the Marland Refining Company bought their first diamond core drill. This was a Sullivan H. machine for cutting 1-inch core, and the drill was first used in Sec. 27 in T. 25 N., R. 3 W., Grant County, Oklahoma. After six months' operation this machine was changed so as to permit of cutting 2-inch core.

The real beginning of the use of the core drills for structure-finding in the north mid-continent area may be said to date from the opening of the main part of the Tonkawa field in Kay and Noble counties. The discovery well of the main part of the field was completed in the SW. corner of the NE. ¼ Sec. 3, T. 24 N., R. 1 W., on June 10, 1922. The surface exposures were such as to prevent mapping of this area by the usual methods, and the Marland Refining Company and the Roxana Petroleum Corporation joined forces in core-drilling this area. Through the courtesy of these companies we are permitted to show the results of this work. Figure 1 shows the structure map based upon the core-drill information and the subsurface structure on the top of the Tonkawa sand. It is interesting to compare this core-drill map with the actual development of the field.

DEVELOPMENT

The success of the core drilling at Tonkawa was so encouraging that work was at once extended to other areas where the presence of favorable structural conditions not provable by other means was suspected. The Marland and Roxana companies were the only ones using the core drill until the Gypsy Oil Company adopted it in March, 1923. These three companies gradually expanded their use of the core drill and are still the largest users of this method of structure finding. In 1925 several other companies began the use of core drills and today there are nine or more companies using about thirty-five drills in Oklahoma and Kansas.

The first drills used were steam-driven drills cutting 1-inch core. Because of the soft nature of the formations penetrated it was soon found that satisfactory core recovery was not made with this small diameter, and a change was made to the use of equipment permitting the recovery of 2-inch core. The use of the steam-driven drills was common practice until the early part of 1924, when Marland Refining Company began experimenting with a Fordson-driven drill. By the



Core drill data

Tonkawa sand data

FIG. 1.—Structure map of Tonkawa field

beginning of 1925 the manufacturers were offering CN- or 2N-type drills equipped with Fordson motor drive and mounted on steel frames and wheels. These drills met with instant favor, and have been adopted by most of the companies doing core drilling.

In the first work with the core drill the single-tube core barrel was used, but this was soon abandoned in favor of the double-tube core barrel.

In this territory most of the drilling was at first in the Wellington shale beds and to comparatively shallow depths. This permitted the use of clear water for circulation. With the gradual extension of operations to the west and with the greater depths necessary to reach reliable key beds, it was found advisable to "fishtail" a considerable part of the hole. At first very little mud was used in the circulation and it was common practice to use a certain amount of casing to keep the holes from caving. With greater experience it was found that by thickening the circulating fluid the walls of the holes could be mudded up to such an extent as to prevent caving, and this removed the necessity for the use of casing. This is probably one of the greatest developments of the past year or so in the use of the core drill in this territory.

Where the key beds lie at considerable depth and there is no advantage in saving records of the upper formations these upper beds are "fishtailed" and the diamond bit is only used on the particular beds upon which correlations are to be based. The ordinary steel fishtail bit will drill probably 15 to 25 feet of sand or sandy shale and then requires replacement by a fresh bit. About nine months ago the first use of the new alloy stellite was tried. Stellite is an extremely hard cobalt-chromium-tungsten alloy. It is applied to the wearing surfaces of the ordinary steel bit by melting and flowing it on by means of an oxyacetyline blowtorch. After applying the stellite the bit is sharpened on an emery wheel. Bits out of gauge must be dressed before applying the stellite. This type of bit was an immediate success and was quickly adopted for use by all of the operators. The stellite-treated fishtail bit has been found to drill from three to five times the footage that the ordinary steel bit will drill, and in areas where the amount of "fishtailing" may be 300 to 400 feet it has increased the footage per drill per month by at least 50

per cent. This has resulted in a greatly decreased cost per foot and has also opened larger areas to the use of this method of determining structural conditions. The adoption of the use of a hard alloy on the wearing surface of the fishtail bit has been one of the greatest forward steps in the development of core drilling.

In the gradual change from clear water circulation to heavy mud circulation there has been brought out the advisability of changing certain mechanical features of the drill. One of these relates to the clearance between the two tubes of the double-tube core barrel, and it has been demonstrated that a slightly greater clearance in the passageway between these two tubes is a decided advantage where heavy mud is used. This has necessitated reducing the diameter of the core by an amount equal to the added clearance between the two tubes. So far, those who have experimented with this new core barrel feel that the advantage of added clearance in the barrel greatly outweighs the disadvantage of a smaller diameter core.

There is dissatisfaction with the present type of core spring or lifter. It is made of tempered steel, and too frequently breaks. Damaged diamonds or a fishing job may result. Experiments are being made with a new type of core lifter, the "Lawson lifter," but it is yet too early to offer an opinion as to its superiority over the present type.

Much experimental work has been done in the effort to find satisfactory substitutes for diamonds. Certain special hard alloys, made up into small sticks, have been tried. They have the advantage of costing much less per bit, and are used where there is steel in the hole, or danger of having the rods stuck in the hole. Stellited sawtooth bits are also sometimes used under such circumstances. Carborundum bits, as substitutes for diamond bits, have been tried without success. As yet no satisfactory substitute for the diamond bit has been found.

Another development, just beginning, pertains to the pump which supplies the fluid for moving the hydraulic feed. As originally designed and used, the hydraulic was connected with the pump which supplied the circulation in the hole, but with the adoption of the use of mud it is obvious that some modification of this practice should be made. As now operated, the pump which supplies the

circulation in the hole also supplies the same mud fluid to the hydraulic. There is a consequent wear on the hydraulic which may very readily be obviated by the use of a separate pump for actuating the feed. The manufacturers are working on this problem and it is only a question of time before they will effect the proper design for a pump for this purpose. It is quite probable that oil or some other fluid may be used in this system rather than water, as the thing could be so arranged as to give a system of high-pressure, low-volume circulation and would not add very much to the size and weight of the equipment already in use. The use of some other fluid than water would remove the danger of having the hydraulic parts damaged by water freezing in them during cold weather. This is a development which will probably take place within the next year.

With the operation of so many drills exploration is gradually advancing westward, where the key beds are found at greater and greater depths. If this westward movement continues it is but a question of time before drills capable of drilling 1,500 feet will be required. The manufacturers are already looking to this possibility and are making tentative designs for such equipment. Where deep drilling is to be done it probably will be found advisable to use a heavier drill, a separate pump for the hydraulic, and two pumps for purposes of circulation. Many other minor improvements in methods of operations and in the design of the equipment probably will be made.

PART II

METHODS OF OPERATION

Organization.—All of the companies have organized their core drill work as a part of their geological departments. It is common practice for the chief geologist to direct the work, although sometimes he delegates this to the district geologist. Under the geologist is a superintendent or foreman who is responsible for the mechanical and economical operation of the drills. The geological phase of the work is cared for by a subsurface geologist, usually in the district office.

The drills are generally operated in groups of two, as this gives a convenient unit, both from the mechanical point of view and from

the point of view of the geologist. The superintendent has charge of all of the mechanical operations of the drills, and he has under him foremen or tool-pushers who have charge of groups of two drills.

Two men are required for the operation of the drill: one a runner and the other a helper. It is common practice to work 12-hour shifts, so that a full crew will consist of two runners and two helpers. By arranging to operate the drills in groups of two it has been found that certain phases of the work can be handled by one man for each group of drills. One water hauler is usually able to keep both drills supplied with water, and one setter is usually able to set the diamond bits for two drills. All units or groups of two drills are practically the same, so that a company operating six drills might have a superintendent and three foremen. Each foreman has under him one truck driver for hauling water and supplies, two drillers, one of whom is a setter, and two helpers.

There is no set rule regarding the handling and interpretation of the core and the application of the information so obtained. Generally the core drill foreman is familiar enough with the formations being drilled to write up a core description and plot a log and know when he reaches the key beds. Sometimes this same man is capable of running the elevations on the core drill holes, or this elevation work may be done by a regular instrument party which does nothing but this kind of work. When satisfactory correlations have been made the subsurface geologist advises the core-drill superintendent where the next location is to be made. The core-drill foreman, or whoever examines the core, sends to the head office a written description of the core or a plotted log with such symbols as will enable the subsurface geologist to interpret it properly.

TYPES OF EQUIPMENT USED

The drills used today are all made by the Longyear or Sullivan companies, and are essentially the same as far as general features of design are concerned. All have the hydraulic feed and all use N rods and cut 2-inch core. Most of the drills are the CN or 2N size, which are capable of drilling to a depth of 900 or 1,000 feet. Some size N drills are in use. Within the last year the manufacturers have been building the 2N- or CN-size drill mounted on a steel frame and

wheels. A Fordson motor is the power unit, and this 20-horse-power motor is able satisfactorily to drive both pump and drill until depths below 900 feet are reached. With the adoption of the gasoline motor for power those companies which had the larger N-type drills installed 60- or 80-horse-power gasoline motors. Some companies are still using the steam-powered drills, and are not yet satisfied as to the advantage of the gas-driven drill. One or two drills using hydraulics with vertical movement of 2 feet have been used, but the disadvantages of this type of equipment probably outweigh the advantages.

Certain operators have used a separate Fordson tractor for driving their pump. This practice permits of a variable pump speed, which is a decided advantage, and it also gives the assurance of having one motor in reserve in case either the drill motor or the pump motor should stop. Where only one motor is used there is danger of stoppage, when the operator will not be able to maintain circulation or raise his rods off the bottom of the hole. In such a case the rods are very likely to "freeze" in the hole, and this is one of the principal reasons for using a separate motor for driving the pump. Other operators meet this danger by having a Fordson tractor on the ground which can be used for raising the rods off the bottom of the hole in case the regular drill motor should go dead.

It is common practice to use a tripod derrick for carrying the sheave for the wire line used in raising and lowering the rods, and for handling casing. It is also common practice to have a small sectionalized house built around the drill for protecting the men from the weather. These houses are light, and are easily knocked down and transported from one location to another.

With the almost universal use of mud instead of water for circulating in the hole it has been found in many cases that the pumps originally designed for use with the drills did not stand the wear incident to such service. As yet there has been no mud pump built for this particular use, but it is only a question of time before the manufacturers will build pumps suitable for handling mud. A great deal of time lost on the drills is due to pump trouble. The sand cuts the liners and valves to such an extent that frequent replacements are necessary. The majority of the operators use a horizontal duplex

$3\frac{1}{2}\times5$ pump for this work. One large operator is using a vertical triplex pump and finds that it gives satisfactory service if it is not packed too tightly. It has been found by experimentation that a rubber sleeve on the plunger of the pump is a decided advantage. This sleeve is designed to be automatically self-packing, so that any wear is taken up by the rubber.

The 2N and CN drills which are being used are capable of going to a depth of about 1,000 feet, but some N-type drills are being used, equipped with larger motors and separately driven pumps, which are capable of going to greater depths.

Many of the drills were equipped at the factory with small electric generators for illumination at night, but in most cases these generators have been found to be too small, and their use is not satisfactory. Usually Coleman gasoline lamps are used about the rig. One large operator is using successfully small installations of Delco lighting equipment, and finds them very satisfactory. Good illumination is a decided advantage and its cost is little greater than that of poor illumination. It is probable that the Delco or some similar system of electric lighting will become general practice within a short time.

"Junk wagons" designed to carry the miscellaneous tools and small pieces of equipment are coming into favor. These wagons have especially designed boxes for receiving particular articles, and in cases of Delco light equipment this is usually built on the wagon. Gasoline and oil barrels are usually built on the wagon. When moving from one location to another the wagon is attached to the rear of the drill.

PART III

PROCEDURE

The first step in drilling a hole is to obtain the permission of the landowner for drilling on his land. Locations are usually made at corners of sections or at the corners of quarter-sections, so that the foreman or superintendent has a choice of four corners for his location. Generally no objection is met with on the part of the farmers, and usually no charge is made by him for entering on his land. In case he has a crop growing, damages are paid to him, the amount usually being agreed upon before the location is made. It is desir-

able, in doing core drill work, that the good will of the farmer be won and retained, and this means that upon the completion of a hole the slush pits should be covered, the fences repaired, and things left in as good condition as before. After arranging with the farmer for the location, the slush pits are dug, usually 6 or 8 feet wide by 12 or 14 feet long. Where considerable "fishtailing" is to be done, two pits are used, one as a settling pit.

By the time the pits are dug the drill is usually on the ground and it is placed in position and leveled up. In summer time it is advisable that the radiator end of the machine be placed toward the direction from which the prevailing winds blow. This is the only occasion for orienting the machine. After the machine is leveled up and the timbers for the flooring placed, the flooring is put down and the next step is the erection of the tripod.

The tripod is raised by power, sometimes from a "cat head" on the drill itself, and sometimes by a tractor. The poles for the tripod are 35 feet in length and give a headroom of about 30 feet between the sheave and the ground. After raising the tripod the bases of the poles are moved so as to center the head sheave over the center of the drill.

With the machine in position and the tripod up, the next step is the erection of the sectionalized house, which requires but a few minutes.

The elevation of the hole above sea-level is usually determined by plane table and alidade as soon as the drill is in position.

While the machine is being erected the water hauler has been filling the slush pits with water, and the core boxes, gasoline and oil barrels, drill rods, casing, miscellaneous tools, etc. have been placed on the new location. It usually requires about eight hours to tear down at one location, move several miles, rig up at the new location, and start drilling.

Where no difficulty is expected in carrying a 3-inch hole to the desired depth the hole is started with a 3-inch fishtail bit. Where it is anticipated that casing will be required, the hole is started with a 4½-inch fishtail bit. It is sometimes necessary to set a few feet of surface pipe to keep sand and gravel out of the hole. If it is necessary to set casing the 4½-inch bit is used to the point where it is desired

to set the casing and a 3-inch fishtail bit is used from there to the point where it is desired to start coring.

The fishtail depths are usually determined by the subsurface geologist, and the superintendent or foreman knows, when he is given the new location, to what depth he can drill with the fishtail. The amount of core recovered is dependent largely upon the character of the formations upon which the correlations are based. In the case of an easily recognizable limestone bed it may be possible to "fishtail" to within a few feet of it and cut only a few feet of core. In cases where dependence must be upon correlations of beds rather than upon any one definite bed it is good practice to get such a sequence of beds as will give an unquestioned correlation. In some areas this requires only 20 or 30 feet of coring, but in others it may require 100 feet or more. In certain parts of Kansas it has been found that considerable hole must be cut with the diamond bit because of the presence of thick beds of gypsum which are not satisfactory markers and which the fishtail bit does not penetrate satisfactorily. In such cases it may be necessary to do a considerable amount of diamond work before the key beds are reached.

As the cost per foot of core recovered is many times greater than the cost per foot of hole made by the fishtail bit, it is desirable to "fishtail" as large a proportion of the hole as possible and to core as little as is consistent with conservative correlations.

In "fishtailing" it is not necessary to withdraw the rods from the hole except when the bit becomes dull, and often the bits will drill several hundred feet before having to be sharpened. When core is being cut it is necessary to withdraw the rods after 10 feet of hole has been made, as the core barrel will accommodate only this amount of core. The core is taken from the core barrel, washed, and placed in trays in proper order. This placing of the core in the tray in proper order is an important point, as it is easy to become confused and place the core in the box in an inverted position. The core boxes usually used are capable of holding about 40 feet of core. The boxes are substantially built and contain two trays. Each tray is three feet long, divided into seven partitions, each of which is $2\frac{1}{4}$ inches wide. Markers are used in the trays to designate the depth from which the

core comes. In cases where a 10-foot run has been made an 8 feet of core recovered, the driller uses his best judgment in determining in what part of the section the 2 feet of missing core should belong, and he indicates this by proper markings in the box.

In fishtail work it is possible to drill several hundred feet per shift. In cutting core, however, the speed is much slower and the average is probably about 30 to 40 feet of core per day. It is usually possible to determine from the first few feet of core where the key bed may be expected, and the foreman or whoever is responsible for making the correlations knows where to expect the other beds. If they appear in the proper order he can determine where he wants to stop the hole and advise his drillers of that fact.

As a general thing, the drills are moved in the daytime, and if they should reach the key bed at night they may either shut down or continue to drill, depending upon the policy of the company for which they work.

Oil and gas is usually bought at tank-wagon prices, delivered at the drill from the nearest town. Other supplies usually have to be obtained from either Garber or Ponca City.

When the hole has been completed a detailed description of the core is sent to the head office and becomes a part of the permanent record. The core is then thrown away.

The operation of tearing down a rig begins with the last run, when the rods are broken out in 10-foot lengths instead of the usual 20-foot lengths. The process of tearing down the rig is almost exactly the reverse of putting it up. The house is torn down first, the tripod is taken down, the flooring removed, and the drill is ready to be moved to the new location.

The information obtained from the core drill holes is usually placed upon a separate subsurface map for this purpose, and the subsurface geologist draws his contours as the work progresses. In plotting the logs a scale of 1 inch to 10 feet is commonly employed. Conventional colors for the different formations are used.

It is usual practice to drill the holes one mile apart, but in cases where abnormal structure or other reasons warrant it, locations are made at half-mile intervals.

PART IV

COSTS

Costs of equipment.—The cost of a 2N- or CN-type drill, gas-driven, mounted on wheels, equipped with 500 feet of rods, is about $7,000 delivered. This drill, if used alone, will require 12 or 13 diamonds of 2½ karats each, which will cost about $4,400. Miscellaneous tools, housing, etc. will cost about $500, making a total of about $11,900. To this must be added the cost of a Fordson tractor, if it is wanted, and also the cost of a truck for hauling water and supplies. To equip two drills, including 500 feet of rods each, 19 diamonds, housings, tools etc., tractor, and a Ford truck costs in the neighborhood of $20,000.

Cost of operation.—The largest single item in the cost of operating core drills is labor. Drillers receive $10 per day for 12-hour shifts. Helpers receive $6 per day. A man who sets bits and also runs the drill, known as a "runner-setter," is paid from $12 to $12.50 per day. Some companies allow 50 cents per day per man for transportation to and from the drill. The truck driver and other labor receives $5 per day. The salaries of superintendents and foremen are conventional. Other items which enter into the cost of operation are gasoline and oil, or fuel, teaming, hauling water and moving drills, operation of trucks and cars, diamond consumption (usually a very small item), repairs to pumps and other parts of machinery, and miscellaneous supplies. Another large item in the cost of operation is the depreciation charged on the equipment. This is different with each company and is a difficult item to estimate. Labor constitutes 50 to 60 per cent of the cost of operation.

Because diamonds are used for cutting the core, and because they cost $110 to $150 per karat, the uninitiated get the impression that the cost per foot for diamonds must be a considerable item. Unless some stones are accidentally broken, the cost of diamonds per foot of hole may be less than one cent per foot. Even allowing liberally for loss from breakage, the cost for diamonds should not be more than 10 cents per foot of hole cored.

The most satisfactory way to figure costs is by using the cost per drill per month. This is the most invariable of all of the cost

figures used, and it is also the figure which can best be used for getting an idea as to the economical operation of the drills. Depending upon upon how depreciation and such charges are handled, the cost of operating a group of two or more drills will range from $1,800 to $2,300 per month per drill. The larger figure includes liberal allowances for depreciation and maintenance of equipment. The cost per drill per month does not vary a great deal even though the total footage drilled per month may vary widely. Using the figure of $2,200 per month per drill it is readily seen that the cost per foot depends upon the depth of hole, the proportion of hole "fishtailed," and amount of time lost. The greatest variable is the depth of hole "fishtailed," and this makes a figure for cost per foot somewhat unreliable as an index to the economy of operations.

There are larger features to this question of cost than are indicated in the paragraph above. The cost per foot may be as high as $2.50 for one month and yet be a more economical operation than the cost of $1.25 per foot for the month previous. The high cost per foot may be due to a large amount of coring and the drilling of several shallow holes as opposed to drilling a few deep holes in the case of the $1.25 per foot cost. Another factor which must be considered is the locations of the holes and the areas which can be proved with a minimum amount of drilling. By proper location of holes it may be possible to prove an area with a much smaller number of holes than if the problem were not properly studied. The cost per acre may be low where the cost per foot of hole is high. It is obvious from this that costs of any nature must be compared with a due regard for the factors involved.

The cost per month is the cost to be emphasized, and it is the cost which must be allowed by anyone planning to undertake core drilling. This cost goes on regardless of the results obtained, and there is no assurance of anything except that this money must be paid out. Cost per foot of hole, cost per acre, and other unit costs may be estimated very closely once it is determined what the cost per month will be. It is possible to go into an area and know that so many feet of hole can be "fishtailed", and that so many feet of core will be required, and that the total depth will be so many feet, and thus arrive at a fairly good idea of the cost per foot of hole and

the cost per acre. Another and entirely different area will probably have about the same cost per month, but the cost per foot of hole and the cost per acre might be quite different.

The developments of the past year, outlined in a preceding paragraph, have greatly reduced the cost per foot of hole and have increased the efficiency of operations. Up to a year ago the average cost per foot of hole was $2. During the past year the average cost, over several hundred thousand feet of hole, has been about $1.50 per foot. The total cost per drill per month probably remains about the same as before. The reduced cost per foot is a reflection of deeper drilling, more efficient fishtailing, etc.

PART V

RESULTS OBTAINED

There are no sure returns for the expenditure of the $2,000 or more per month per drill which a company incurs when it undertakes core drilling. By the law of averages it is probable that a good return on the money spent in this way can be obtained, but it might be necessary to drill for several years before such returns would show.

Even though no productive structures are found, all money spent for core drilling is not lost. Knowledge of the absence of favorable structure permits cancellation of leases, and some money is saved in that way.

The example of Tonkawa, already cited, inspired most of the core drilling, but this success has been followed by others until today there is a considerable list of pools which have been discovered with the aid of the core drill. These include, in Oklahoma: (1) the Thomas pool, in T. 25 N., R. 2 W.; (2) the Hubbard pool, in T. 26 N., R. 2 W.; (3) the North Braman pool, in T. 29 N., R. 1 W.; (4) the South Braman pool, in T. 28 N., R. 1 W.; (5) the Deep Rock pool, in T. 18 N., R. 3 E.; and (6) the Hunnewell pool, in T. 29 N., R. 2 W. In Kansas are (7) the Padgett gas field and (8) the Graham pool. All of these were discovered largely with the aid of the core drill. These discoveries would more than pay for all of the core drilling which has ever been done. Other areas which have been explored with the core drill and which are now being tested are: Sec. 19, T. 23 N., R. 3 W.; Sec. 34, T. 24 N., R. 3 W.; Sec. 6, T. 24 N., R. 2 W.;

Sec. 23, T. 20 N., R. 4 E.; Sec. 33, T. 26 N., R. 3 W.; Sec. 2, T. 20 N., R. 5 W.; Sec. 9, T. 20 N., R. 4 W.; Sec. 29, T. 23 N., R. 4 W.;

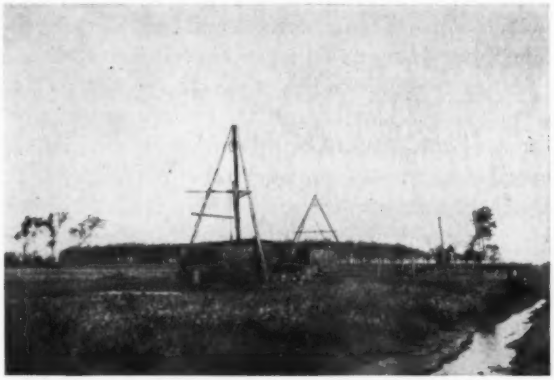


FIG. 2.—Core drilling by two different companies at the same section corner

Sec. 18, T. 22 N., R. 2 W.; Sec. 2, T. 27 N., R. 3 W.; and possibly many others.

FIG. 3.—Core drilling by one company while structure is being tested by another company.

It may safely be said that, from the large economic point of view, core drilling is not only justified, but has paid large dividends;

however, there are individual users of the core drill who have made considerable investments and are yet waiting to get their returns.

Under the present competitive system there is a large amount of duplication and consequent economic loss. Certain areas have been drilled by as many as six companies. It is becoming commonplace to see two machines drilling at the same section corner (Fig. 2). Illustrative of competition between the companies is Figure 3, which shows one company core drilling while the structure is being tested by another company.

As the more attractive areas are being drilled, leaving the less attractive areas for the future, it is likely that the results from now on may not be so encouraging as they have been in the past. Drilling must of necessity be farther west and deeper, and in areas which have heretofore been looked upon with little favor.

GEOLOGICAL NOTES

HAUERITE IN A SALT-DOME CAP ROCK

An interesting discovery of hauerite (MnS_2) has been made in the cap rock of the Big Hill salt dome, Matagorda County, Texas. This dome is also known as Gulf, and is owned and operated for sulphur by the Texas Gulf Sulphur Company. So far as the writer knows, this mineral has not previously been observed in any of the gulf coastal domes. It was first found in a well drilled on the south-central part of the cap-rock area. A core at 1,009 feet to 1,012 feet, or 65 feet below the top of the cap rock, contained several crystals and fragments. The two most nearly

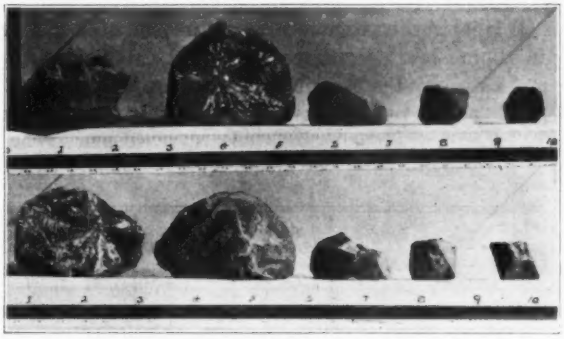


FIG. 1.—Specimens of hauerite from Big Hill salt dome

perfect crystals are octahedrons truncated by cubes; their crystallographic axial lengths are one inch. A globular cluster of crystals, two and one-half inches in diameter, was picked up by the core barrel at a slightly greater depth. The outer surface of this cluster shows crystal faces of octahedrons truncated by cubes; the internal structure is radiating. These crystals are shown in the accompanying photograph (Fig. 1). Quantitative determinations on some scraps of this mineral gave 46.1 per cent manganese and 52.5 per cent sulphur. A specific-gravity test on a clean crystal of the mineral showed 3.49. Scores of small octahedral crystals and bunches of crystals without distinct form were found in a core at 994–98 feet, or 36 feet below the top of the cap rock, and at greater depth in the anhydrite zone in a second well about 300 feet from the first one mentioned.

Regarding hauerite, Dana[1] says, in part:

Isometric, pyritohedral. Commonly in octahedrons; sometimes in globular clusters. Cleavage: cubic, imperfect. Fracture, uneven to subconchoidal. Brittle. H.=4. G.=3.463. Luster, metallic, adamantine. Color, reddish-brown, brownish-black. Streak, brownish-red. Composition: MnS_2=Sulphur, 53.9 per cent; manganese, 46.1 per cent.

From Kalinka, Hungary, in clay with gypsum, sulphur, and realgar in a region like a solfatara; trachytic and other eruptive rock decomposing and adding to the clay, and the sulphur given off at the same time making depositions of sulphur and sulphates. One crystal found measured $1\frac{1}{4}$ inches through. . . . . Also in the crystalline schists of the Wakalipu district, New Zealand (Cox, *Transactions New Zealand Institute*, Vol. 14, p. 426, 1881). At Raddusa, Catania, Sicily, in octahedral crystals at a depth of 50 meters imbedded in clay carrying layers of sulphur, gypsum, and calcite.

The hauerite at Gulf conforms to the mineral properties as set forth by Dana. It is interesting to note that this mineral occurs elsewhere, as at Gulf, in sulphur-bearing calcareous and gypsiferous rocks.

The rocks in which the hauerite was found are limestone and calcareous clay, with a little pyritiferous sandstone, and anhydrite. In the anhydrite the hauerite was found associated with pyrite and galena. Partial analyses of the limestone and clay are as follows:

	Insol. (Percentage)	$CaCO_3$ (Percentage)	$CaSO_4$
Limestone.....	1.4	93.0	Tr
Clay.....	37.8	51.2	nil

The writer is indebted to Mr. James W. Schwab, chemist for the Texas Gulf Sulphur Company, for the chemical and physical tests made.

ALBERT G. WOLF

GULF, TEXAS

[1] J. D. Dana, *System of Mineralogy*, p. 87.

REVIEWS AND NEW PUBLICATIONS

Structure in North Haakon County. By FREEMAN WARD, *South Dakota Geological and Natural History Survey, Circular 22,* March 19, 1925.

The search for oil in South Dakota has been handicapped by the difficulties that attend finding and mapping structure in regions where the surface rocks are poorly consolidated shales and by the failures that of necessity followed attempts to find oil on pseudo-anticlines based on erroneous observations. *Circular 22* is valuable in that it announces a conclusion, evidently born of long experience, that "Real deformation can only be successfully worked out in this plains region by the use of key beds. Dip readings have proved to be inadequate." This statement would carry small comfort to geologists whose hasty *reconnaissances* in South Dakota had failed to reveal any strata that could be traced with certainty were it not for the additional statement, "It is with great pleasure that we record the presence of a reliable, usable key bed."

The evidence that horizons were found that could be traced is given on a structure contour map covering parts of two townships, which shows gentle folding of the key beds in the Pierre shales. These small folds would be perhaps only of academic interest were it not that they apparently are superposed on a regional fold that extends northeast through Pennington, Meade, and Haakon counties. This regional fold is indicated by the elevations of the top of the Pierre formation. Of course it is possible that this apparent arch is in fact due to post-Pierre erosion, but it seems much more probable that this structure, based on actual elevations on the top of the Pierre, represents true deformation than that the structural conditions are accurately depicted on earlier maps where the key horizon is the top of the Dakota sandstone, for Professor Ward points out that "there is a continuous tract involving some 17,000 square miles in which there is not a single well to the Dakota."

K. C. HEALD

THE ASSOCIATION ROUND TABLE

MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA

February 18, 1926

Mr. E. L. DeGolyer
65 Broadway
New York, N.Y.

DEAR MR. DEGOLYER:

As you no doubt are aware, the Geological Society of America is to meet at Madison during Convocation Week of 1926. The Local Committee wishes to extend from the Department of Geology of the University of Wisconsin and the Geological Survey of the State of Wisconsin, a cordial invitation to the American Association of Petroleum Geologists, collectively and individually, to attend this meeting. The chairman of the Local Committee would appreciate having information from those contemplating attendance in order that circulars relating to plans may be forwarded and preparations made for the reception and entertainment of the visiting petroleum geologists while they are in Madison. Kindly convey this invitation to the Association at the time of the Dallas meeting, and if it is possible, I suggest that the invitation be incorporated in one of the circulars distributed during the meeting. The Association will also receive an invitation to attend the Madison meeting from the Council of the Geological Society of America.

Very truly yours,

THE LOCAL COMMITTEE:
E. F. BEAN
A. N. WINCHELL
W. H. TWENHOFEL, *Chairman*

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The Executive Committee has approved for publication the names of the following applicants for membership in the Association. This does not constitute an election, but places the names before the membership at large. In case any member has information bearing on the qualifications of these applicants, please send it promptly to Fritz Aurin, Ponca City, Oklahoma.

(Names of sponsors are placed beneath the name of each applicant.)

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Roy J. Metcalf, Fort Worth, Tex.
H. T. Beckwith, W. E. Wrather, Noah C. Adams
John Moir, Houston, Tex.
Roland B. Paxson, Fred B. Plummer, R. D. Goodrich
Leo W. Petree, Oregon, Mo.
Thomas B. Romine, U. R. Laves, Joseph T. Kent
William Quilliam, Houston, Tex.
George Sawtelle, W. F. Henniger, L. P. Garrett
John B. Reeside, Jr., Washington, D.C.
C. E. Dobbin, W. W. Rubey, Julian D. Sears
Robert P. Reid, Bartlesville, Okla.
W. L. Walker, A. F. Morris, E. P. Hindes
Kenneth C. Sclater, Bartlesville, Okla.
E. P. Campbell, R. R. Brandenthaler, W. W. Scott
R. J. St. Germain, Tulsa, Okla.
Ralph E. Davis, H. C. George, M. M. Valerius

Paul L. Vaudoit, Dallas, Tex.
W. E. Wrather, Frank W. Reeves, R. B. Whitehead
Robert D. Vernon, Tampico, Mexico
Walt M. Small, Paul Weaver, John M. Muir
Paul R. Yewell, Tulsa, Okla.
Wayne Loel, Robert T. Hill, O. M. Edwards

FOR ASSOCIATE MEMBERSHIP

Homer L. Anderson, Fayetteville, Ark.
Gail F. Moulton, Albert W. Giles, V. O. Tansey
Hillis F. Bell, Tulsa, Okla.
Roy A. Wilson, V. E. Monnett, G. E. Anderson
Walter J. Boyle, Fort Worth, Tex.
H. T. Beckwith, S. W. Wells, Thomas W. Leach
Carl F. Buchner, Oklahoma City, Okla.
Calvin T. Moore, W. H. Twenhofel, G. E. Anderson
Selwyn O. Burford, San Angelo, Tex.
Floyd C. Dodson, James V. Howe, W. F. Bowman
Ronald L. Camp, Wichita Falls, Tex.
M. M. Garrett, Robert N. Kolm, William E. Hubbard
Ian Campbell, Baton Rouge, La.
Henry V. Howe, W. G. Barrett, Robert D. Longyear
E. Gail Carpenter, Pittsburgh, Pa.
Roswell H. Johnson, R. E. Somers, L. G. Huntley
William A. Clark, Jr., Houston, Tex.
Willis Storm, E. B. Wilson, D. D. Christner
Louis E. Cotulla, Thurber, Tex.
Reuben E. Cotulla, Fred B. Plummer, David Donoghue
Rama T. Dallas, Konawa, Okla.
Orlan L. Dallas, Owen A. Winsor, Chester A. Hammill
Edward B. Dana, Pittsburgh, Pa.
Roswell H. Johnson, R. E. Somers, L. G. Huntley
Beecher J. Dining, St. Francisville, Ill.
Bond Coleman, I. J. Vernon, Rae Preece
Robert H. Durward, Wichita Falls, Tex.
Melvin J. Collins, Clarence E. Hyde, Wallace C. Thompson
Agnes M. Farrell, Washington, D.C.
Sidney Powers, Dollie Radler, David White
Harold M. Fritts, Dallas, Tex.
N. W. Bass, Thomas B. Romine, R. S. Knappen
Harvard Giddings, Eastland, Tex.
H. T. Beckwith, Albert S. Clinkscales, J. M. Armstrong
John M. Giles, El Dorado, Ark.
G. C. Potter, James J. Jones, Everett Carpenter

William W. Harvey, Cisco, Tex.
L. B. Benton, Willard L. Miller, Clarence M. Sale
Karl F. Hasselmann, Colorado, Tex.
Leonard W. Orynski, S. H. Gester, M. M. Valerius
E. Manuel Hawtop, Austin, Tex.
E. H. Sellards, F. L. Whitney, Fred M. Bullard
Hollis D. Hedberg, Ithaca, N.Y.
C. M. Nevin, R. S. Knappen, Floyd Hodson
Kenneth E. Hickok, Golden, Colo.
F. M. Van Tuyl, Max W. Ball, Charles M. Rath
Baker Hoskins, Jr., Waco, Tex.
Thomas B. Romine, Joseph M. Dawson, Hal P. Bybee
Willy Jenny, Houston, Tex.
Roscoe E. Shutt, Angus McLeod, G. R. Henson
Roy P. Lehman, Holdenville, Okla.
H. T. Beckwith, R. S. Knappen, R. J. Riggs
Lewis W. MacNaughton, Houston, Tex.
R. E. Rettger, V. E. Monnett, Wallace E. Pratt
Eldridge D. Phillips, Lake Charles, La.
Wallace E. Pratt, Dilworth S. Hager, Fred B. Plummer
Olive C. Postley, Washington, D.C.
David White, W. C. Mendenhall, W. T. Thom, Jr.
Nelson B. Potter, Tulsa, Okla.
G. C. Potter, James J. Jones, Noah C. Adams
Willard W. Rusk, Denver, Colo.
Junius Henderson, J. S. Irwin, W. E. Rennie
J. Howard Samuell, San Angelo, Tex.
E. C. Edwards, S. M. Aronson, Irving Perrine
Hugh C. Schaeffer, Oklahoma City, Okla.
S. Weidman, V. E. Monnett, Roy A. Wilson
T. O'D. Shelton, Coleman, Tex.
Joseph T. Kent, V. E. Monnett, J. V. Howell
Michael A. Smirnoff, Houston, Tex.
W. van Holst Pellekaan, A. T. Schwennesen, J. Brian Eby
Gene R. Smith, Mexia, Tex.
R. D. McCluer, Walter M. Burress, Willis Storm
Gerald N. Smith, Oklahoma City, Okla.
S. Weidman, V. E. Monnett, G. E. Anderson
Arthur F. Striker, Coleman, Tex.
Thomas B. Romine, Anthony Folger, Harold T. Morley
Hans E. Thalmann, Tampico, Mexico
F. E. Wellings, John M. Muir, Alfred P. Frey
Alex Tiedemann, Tampico, Mexico
F. E. Wellings, John M. Muir, Paul Weaver

Merwin B. Tucker, Pittsburgh, Pa.
Roswell H. Johnson, R. E. Somers, L. G. Huntley
Warren H. Wynn, Tulsa, Okla.
R. C. Moore, R. S. Knappen, A. L. Selig
Claude T. Young, Norman, Okla.
Roy A. Wilson, G. E. Anderson, V. E. Monnett

FOR TRANSFER FROM ASSOCIATE TO FULL MEMBERSHIP

J. B. Blanchard, San Antonio, Tex.
Joseph M. Dawson. L. K. Barrow, S. W. Wells
Glenn O. Briscoe, San Angelo, Tex.
Fred B. Plummer, D. D. Christner, Dilworth S. Hager
Erdice R. Brockway, Marshall, Ill.
E. L. Roark, S. D. Butcher, E. C. Moncrief
Ernest W. Brucks, Tampico, Mexico
Wallace E. Pratt, David Donoghue, Alexander Deussen
Robert L. Cannon, Dallas, Tex.
Wallace E. Pratt, E. Russell Lloyd, Alexander Deussen
O. A. Disney, Wichita Falls, Tex.
J. L. Tatum, T. C. Sherwood, Jr., Roger W. Sawyer
Charles I. Jennings, Fort Worth, Tex.
David Donoghue, Reuben E. Cotulla, J. D. Thompson, Jr.
Boone Jones, Blackwell, Okla.
W. C. Kite, Irving Perrine, E. C. Moncrief
George A. Kroenlein, Tulsa, Okla.
W. B. Wilson, W. E. Bernard, Harry H. Nowlan
Laura Lee Lane, Houston, Tex.
Alexander Deussen, John R. Suman, W. F. Bowman
Lester A. Luecke, Wichita Falls, Tex.
M. M. Garrett, Wallace C. Thompson, H. B. Fuqua
Lowell J. Ridings, New York City
Paul Weaver, E. Ordoñez, F. H. Kay
John F. Weinzierl, Houston, Tex.
Alexander Deussen, Wallace E. Pratt, F. L. Aurin

ELEVENTH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS, DALLAS, TEXAS, MARCH 25–27, 1926. E. DEGOLYER, PRESIDING

INTRODUCTORY REMARKS TO TECHNICAL PROGRAM, DALLAS MEETING

The technical program for the Dallas meeting has been built up around four major themes—a symposium on the origin of oil and a discussion of three highly

specialized methods of searching for and deciphering buried or obscure structural features, namely, geophysical apparatus, micropaleontology, and core drilling.

The first topic, dealing with the origin of oil, we have ever with us, an unanswered query which today arouses as active and diverse discussion after years of speculation as it did when petroleum geology was in its infancy. We are agreed, perhaps, that oil is of organic origin, but at that point our agreement ends. We are unable to state with certainty the types of organic life, whether plant or animal, which contributed the hydrocarbons from which any particular type of oil was evolved. We are in doubt as to whether it originated in liquid form or passed through its primary stages as a solid. Our efforts as petroleum geologists have been largely directed toward methods of locating structure, and this continues to be our major aim, as is amply demonstrated by this program.

We are hunters in pursuit of game whose habits we understand imperfectly. We have perhaps discovered the favorite type of hiding place of our quarry, but the familiar haunts are rapidly being hunted out; and if we expect to succeed in the future in locating new sources of oil it is of vital importance that we acquire a more intimate acquaintance with the object of our efforts.

Hence a discussion of the origin of oil will remain a timely topic perhaps for some time to come, and it will continue to be worth our while occasionally to take stock of our theories and try to reach some conclusion as to how far we have succeeded in reducing them to demonstrated facts.

Petroleum geology is in a constant state of flux, and an active and adaptable mind is required to keep pace with its progress. It is perhaps well to consider that ten years ago, when this Association was organized, it would have been preposterous to have proposed any one of the three remaining topics dealt with in this program for general discussion in a gathering of petroleum geologists. Geophysical apparatus was looked upon with scorn and was classed in the category with the "wiggle-stick"; micropaleontology was of only academic interest, and received serious consideration only by a limited few engaged in the study of abstract science; core drilling was considered an expensive and useless waste of time, and, in the United States at least, was scarcely thought of as a means of locating structure in regions where surface evidences were wanting.

Today a new school of specialists are devoting their entire time to phases of geology which only a few years ago were scarcely thought of, and which are proving indispensable to the prosecution of the oil industry. The use of geophysical apparatus has been justified by the discovery of a number of salt domes which offer the prospect of a substantial potential source of oil in the Gulf Coast; and it begins to be evident that such apparatus can be applied successfully to deciphering structure outside the salt-dome region. Core drilling has proven its effectiveness so conclusively that it is now in general use by most of the important oil companies of the Mid-Continent region. And a knowledge of micropaleontology has been instrumental in establishing definite horizon markers in the midst of formations which previously defied differentiation.

Petroleum geology has in recent years been so split up into highly specialized fields that no one individual can any longer be equally proficient in them all. Not all of us aspire to own or operate a torsion balance or seismograph, nor do we hope to be on terms of familiar speaking acquaintance with the myriad microscopic forms of fossil life entombed in oil-field formations. Yet we cannot afford not to know something about the technique of these several groups of our fellow-workers, if for no other purpose than to be able to formulate an independent individual appraisal of their relative value toward solving the problems with which we have to deal in our profession.

The foregoing considerations have inspired the program committee to solicit the papers on specialized subjects which are presented at this meeting. With them have been incorporated as many regional papers dealing with subjects of timely interest as the available time will permit.

W. E. WRATHER

REPORT OF THE PRESIDENT

I do not propose to make a formal report; in fact, I am not certain that there is much need for me to make any report at all. There has been a regular blizzard of postcard ballots, circulars, and letters of my own flying around, so that I imagine that the business of the Association is fairly well known.

One of the questions that the executive committee had to consider when it came into office was that of a permanent employee for the Association. The executive committee met in Tulsa, and decided in favor of securing a hired officer or employee, and of opening offices for the Association. I think that words such as "permanent headquarters," have been carelessly used, and things of that sort have rather confused the issue. The matter has been held open until this meeting, so that it can come back to the Association itself. The majority of the executive committee believe that the resolution pertaining to the matter which was passed at Witchia was sufficient authority for action by the committee. There are members of the executive committee, including myself, who felt that the Wichita resolutions were rather irregularly stated, and the best thing to do was to hold the matter over and place it before this meeting for decision.

There are two other problems, assuming that you are ready to consider a permanent employee for the Association; one is the problem of the man, and the other is that of finances. As to the question of the man, it is only lately that we have had any candidates that have been worthy of consideration. As to finances, practically nothing has been done. I judge that the sentiment of the Association is that you do not want another increase in dues at the present time. Personally, I have believed, and still believe, that arrangements can be made for financing outside any of the towns that have expressed a desire for the office and have agreed to furnish offices and pay part of the expense, but I think that this is a step in which, if you want to take it after giving it consideration, it is best not to be beholden to any town. I would like to see the money

raised by those members of the Association who felt that they could contribute to it, rather than by some individual groups that were bidding for the office.

The growth of the Association has been greater during the past year than in any other year of its history. I have been surprised at this, as I felt that the membership at the beginning of the Association year had probably pretty well covered the field. There have been only two years when the accessions to membership were more than two hundred, and last year was one of them; the increase last year was two hundred and fifty-one.

The other steps that have been taken are familiar to you. One is the changing of the *Bulletin* to a monthly publication. You know, of course, that the salt-dome papers have been collected and published separately. You probably also know that the Research Committee has continued its work, and efforts, and that the possibility of research in petroleum as a whole has made a tremendous step forward during the past year by the donation by Mr. Rockefeller and by one of the oil companies to the American Petroleum Institute, to be used in the research of petroleum, covering chemistry, geology, and physics. The officers of the association have co-operated with Dr. David White, of the Division of Geology and Geography of the National Research Council, and with Mr. Heald and the special committee of the National Research Council, to try to see that geological needs are properly represented in the allocation of these funds whenever it shall be made. Of course, I suppose it will actually boil down to a sort of competition between the chemists and geologists, with the chemists better organized than we are, or knowing their problems better than we do.

I believe that covers fairly well such matters as I should call to your attention at this time, but I shall be glad to answer to the best of my ability any questions any one has to ask at any time during the meeting.

Respectfully submitted,

E. DEGOLYER

REPORT OF THE SECRETARY

Membership of the Association:

Number of members May 19, 1917 (first published list)		94
Number of members February 15, 1918		176
Number of members March 15, 1919		210
Number of members March 18, 1920		392
Number of members March 15, 1921		621
Number of members March 8, 1922		767
Number of members March 20, 1923		901
Number of members March 22, 1924		1,080
Number of members March 21, 1925		1,253
Number of active members March 20, 1926	1,080	
Number of associate members March 20, 1926	424	
Total number of members March 20, 1926		1,504
Increase in membership for this year		251

Applicants elected, dues unpaid	39	
Applications approved for publication	62	
Recent applications	25	
Total applications on hand		126
Number of members withdrawn	13	
Numbers of members dropped	7	
Number of members died	4	
Number of members in arrears 1924–25–26 dues	15	
Number of members in arrears 1925–1926 dues	20	
Active members in arrears 1926 dues	284	
Associate members in arrears 1926 dues	112	
Total members in arrears 1926 dues		396
Members paid dues in advance January 1, 1926		34

Distribution of publications:

1. Subscriptions		
Libraries (domestic, 92; foreign, 10)	102	
Companies (domestic, 43; foreign, 13)	56	
Individuals (domestic, 65; foreign, 19)	84	
Total subscriptions		242
Increase in number of subscriptions		50
Subscriptions paid in advance of January 1, 1926		104
2. Exchanges, etc		17

Respectfully submitted,

CHARLES E. DECKER, *Secretary*

REPORT OF THE TREASURER

AUDITOR'S STATEMENT

We have made a detailed audit of your records for the Fiscal Period, March 18, 1925 to March 18, 1926, and submit herewith: "Statement of Receipts and Disbursements, with Supporting Schedules for the year examined."

All receipts were checked and traced into your depository banks. Disbursements Vouchers were checked into your books of original entry, and paid invoices and receipts found to support them all. Your investments were verified by actual count, and your cash proved—as per reconciliations herewith. Your records bear evidence of having been very carefully and conscientiously kept, and were easily verified in detail. We wish to thank your Secretary-Treasurer, and Mrs. C. E. Decker, who has kept the books, for assistance rendered us during this examination. The accompanying figures present the true condition of your Association at March 18, 1926.

Yours very truly,

PATTERSON, SCHIFF AND HILL

Public Accountants

(*Signed*) BY A. E. HILL

STATEMENT OF RECEIPTS AND DISBURSEMENTS

MARCH 18, 1925 TO MARCH 18, 1926

Cash in Banks at March 18, 1925 (Auditor's Report)			$ 5,009.56
RECEIPTS FOR FISCAL YEAR:			
Associate dues	$ 3,458.00		
Full membership dues	14,999.75		
Total membership dues		$18,457.75	
From Bulletin:			
Subscriptions	2,971.25		
Sale bound copies	1,461.90		
Sale back numbers	2,052.32		
Advertising	915.54		
Separates	12.00		
Total receipts from *Bulletin*		7,413.01	
Other:			
Interest earned on investments		816.36	
Miscellaneous		5.87	
Total receipts for fiscal year			26,692.99
Total funds handled for fiscal year			$31,702.55
DISBURSEMENTS FISCAL YEAR:			
Bulletin:			
Editor's salary	$ 600.00		
Editor's postage, supplies, telephone, telegraph	63.50		
Chicago editorial secretary	1,239.28		
Chicago editorial expense	37.54		
Drafting and blue prints	64.00		
Advertising manager expense	28.32		
Total editorial		$ 2,032.64	
Printing (University of Chicago Press):			
Balance binding Vol. 8	295.00		
Printing Vol. 9 No. 1	1,558.22		
9 No. 2	1,971.15		
9 No. 3	2,413.78		
9 No. 4	938.00		
9 No. 5	736.78		
9 No. 6	922.76		
9 No. 7	792.41		
9 No. 8	1,055.28		
9 No. 9	943.69		

10 No. 1	$ 1,016.26		
10 No. 2	1,065.34		
Total printing regular issues		$13,708.67	
Other expenses:			
Stencil corrections and mailing	766.20		
Cloth binding	640.00		
Printing separates	735.74		
Storage, freight and drayage	60.50		
Total other expenses		2,202.44	
Total publication expense		$17,943.75	
Total funds handled for fiscal year			$31,702.55
General office expense:			
Secretary-treasurer salary	900.00		
Clerical help	1,299.15		
Printing	364.81		
Postage	372.66		
Office supplies	363.27		
Exchange and refunds	51.60		
Protested checks (all made good but $15.00)	130.25		
Bond for treasurer	70.00		
Unclassified	44.16		
Telephone and telegraph	12.84		
Express	15.03		
Total general office expense		3,623.77	
Expense of meetings:			
Printing (convention notice, pamphlets and programs)	283.64		
Clerical help and expense	41.10		
Authorized expense of officers and guests	342.51		
Badges	64.50		
Total expense of meetings		731.75	
Other expense:			
Executive expense	77.37		
Research committee	116.73		
Total other expense		194.10	
TOTAL ALL EXPENSES			22,493.37
UNEXPENDED BALANCES IN BANKS			$ 9,209.18

Investments on hand, March 18, 1926 (see Schedule)	$17,400.00
Cash on hand, March 18, 1926	9,209.18
Cash and investments in treasurer's hands, March 18, 1926	$26,609.18

SUMMARY OF FISCAL YEAR ENDING MARCH 18, 1926

Total receipts for period	$26,692.99	
Total disbursements for period	22,493.37	
Net gain for period	$ 4,199.62	
Cash and investments in treasurer's hands March 18, 1925	22,409.56	
Gain for year	4,199.62	
Cash and investments in treasurer's hands March 18, 1926		$26,609.18

Schedule of interest-bearing bonds and investments, March 18, 1926:

	Cost:	
United States Treasury Certificates	4,100.00	(Par $5,000.00)
Wyoming Farm Loan	800.00	
Northern States Power (6%)	1,500.00	
Imperial Japanese Bonds (6½%)	500.00	
Nevada California Elec. Bonds (5%)	5,000.00	
Anaconda Copper Co. (6%)	1,000.00	
Wilson & Co. (6%)	1,000.00	
Pondera County Bonds (5½%)	1,000.00	
Hardin County, Texas, Bonds (5%)	1,000.00	
St. Louis & San Francisco Ry. (5%)	500.00	
United States Rubber (5%)	1,000.00	
TOTAL	$17,400.00	

Bank reconciliations

First National Bank of Norman, Okla., March 18, 1926:

Balance as per bank statement		$ 5,645.61
Outstanding checks, No. 36	$ 2.00	
No. 38	55.87	
No. 39	13.76	
No. 40	2.00	
No. 41	1,065.34	
Total outstanding checks		1,138.97
Balance as per books		$ 4,506.64

Security National Bank of Norman, Okla., March 18, 1926:

Balance as per bank statement		$5,066.01
Outstanding checks, No. 17	$ 300.00	
No. 21	12.50	
No. 22	19.91	
No. 23	31.06	
Total outstanding checks		363.47
Balance as per books		$4,702.54

Respectfully submitted,

CHARLES E. DECKER, *Treasurer*

REPORT OF THE EDITOR

The secretary-treasurer has referred in his reports to items bearing on the *Bulletin*, which makes unnecessary any detailed statement by the editor. There has been a gradually mounting expense of publication which parallels the increasing size of the publication, and is in accord with the general policy of the Association to encourage publication of researches of its members rather than to scrutinize very sharply and to curtail such publication. There have been relatively few papers which have not found ultimate publication, and at the present time there are no papers in the editor's hands which have not been acted on in one way or another.

The inauguration of the monthly issue of the *Bulletin* is occasioned by the increasing size of the bi-monthly numbers. This change will make possible improvements beyond anything which has been attempted in the *Bulletin* in the direction of having in the pages of our publication more current facts about petroleum geology, new developments, and the like. The members will be kept more closely in touch with Association matters, and it is hoped that the departments dealing with geological notes, current reviews, and others will be considerably enlarged. These considerations influenced the executive committee in the formulation of a plan for a permanent office with a man working full time as editor and secretary-treasurer. I favor strongly this change in policy which will permit development in efficiency, and may be expected to aid in financing the *Bulletin* by increasing the scope of worth-while advertising. It has not been possible for the present editor to contribute more of his time than he has given, and accordingly, though he relinquishes the work with regret, he believes the change in management of the *Bulletin* will increase greatly its value.

Possibly some of the members have felt that we have had a little bit "salty" taste in the *Bulletin* this year, and have missed papers from districts outside of the Gulf Coast. It may be reported that the papers submitted to the editor have appeared in the *Bulletin*, and any lack of writing on certain districts

reflects largely the neglect of some of the members in contributing to the *Bulletin*.

In approving for publication in a separate volume the salt-dome papers, the Association has done a notable piece of work, which will probably stand for the next decade or two as the chief source of information on a most interesting and important type of geologic structure and a significant phase of petroleum geology. As regards the financing of this particular volume, we shall surely find that the cost will more than be cared for by the sales. If that is not true we shall have been very much mistaken. It is planned to sell the book, which has about 850 pages, for $5.00, and it is a liberal $5.00 worth of scientific information. The sale of 350 copies will put the Association in the clear, and additional sales should constitute a source of profit.

In closing, I should like to express sincerely the large amount of pleasure that I have had, despite the labor that editorial work inevitably involves. The opportunity which this task has given to be of some service to the Association has carried its own recompense, and as I turn over the editorial work to another, I do not want to do that without expressing to you appreciation of the honor you have done me in giving me charge of this very important Association work, and to express in a measure my regret in having to relinquish it.

Respectfully submitted,

RAYMOND C. MOORE, *Editor*

As Mr. Heroy was not present, no report of the advertising manager was made.

REPORT OF THE GENERAL BUSINESS COMMITTEE

The following report of the General Business Committee was adopted:

WHEREAS, This Association's increased size and greater scope of activity require a further development of methods for carrying on its work:

AND WHEREAS, The Association in annual meeting assembled in Wichita, Kansas, in March, 1925, authorized the executive committee to study and in its discretion modify the methods of carrying on the Association's business:

AND WHEREAS, The executive committee has, through the President and Vice-president, in whose hands it placed the matter, devoted much time to such a study, but has not yet put into effect the results thereof:

Now, therefore be it resolved, that the incoming executive committee and its successors be and they are hereby empowered and instructed to select and employ, whenever such action can be initiated without increase of membership dues, a full-time business manager, not a member of the executive committee, who shall carry on, under the direction of the committee, the secretarial and editorial work of the Association and such other work as in the committee's opinion properly may be assigned to him; and the committee is further empowered and instructed to fix and establish headquarters at which such work shall be performed.

The General Committee recommended that the executive committee investigate the question of life memberships, to be used as a fund to defray the heavier expenses of permanent headquarters.

W. E. WRATHER, *Chairman*

FRITZ AURIN	V. E. MONNETT
A. L. BEEKLY	D. W. OHERN
GEORGE E. BURTON	SIDNEY POWERS
A. F. CRIDER	WALLACE E. PRATT
ELMER F. DAVIS	LOUIS ROARK
DAVID DONOGHUE	J. M. SANDS
H. B. FUQUA	H. G. SCHNEIDER
GEORGE C. GESTER	I. R. SHELDON
K. C. HEALD	WALTER M. SMALL
W. B. HEROY	JOHN R. SUMAN
EUGENE HOLMAN	CHARLES H. TAYLOR
JOSEPH JENSEN	ARTHUR F. TRUEX
MARVIN LEE	LUTHER H. WHITE
C. R. MCCOLLOM	W. B. WILSON
ALEX W. MCCOY	

President DeGolyer asked for a resolution from the Association sponsoring the publication of a quarterly journal of micropaleontology. Dr. Schuchert moved that the Association express its approval of the founding of this publication, giving the executive committee power to take the necessary steps. The motion was seconded and carried.

Mr. A. F. Truex extended the invitation of the Tulsa Geological Society to hold the 1927 meeting of the Association in Tulsa, Oklahoma.

REPORT OF THE RESOLUTIONS COMMITTEE

PART I

WHEREAS, the American Association of Petroleum Geologists in convention assembled at Dallas, Texas, has enjoyed a most successful technical program, delightful entertainment, and unusual hospitality, and

WHEREAS the Association desires to express its appreciation of the fruits of the meeting, now therefore be it

Resolved by the members of the American Association of Petroleum Geologists that the Association so express and record its thanks and appreciation to all who have made the convention so successful, with especial mention of the Dallas Society of Petroleum Geologists and R. B. Whitehead, the general chairman; The Baker Hotel for the successful way it has served the members and guests; The Dallas Chamber of Commerce; the oil companies, with especial mention of the Atlantic Oil Producing Company; Mr. Nathan Adams; the local business men; the automobile agencies, and the Baker Garage; the city administration; the railroads that, for the first time, have granted rates in the United States and Canada; the Brook Hollow Country Club; the Adolphus Hotel for

its luncheon to the ladies; the local ladies' society; and to Mr. J. Wallace Bostick for the permanent golf trophy.

The secretary will forward a copy of this resolution to each of the organizations and individuals mentioned.

PART II

WHEREAS, during the past year this Association has lost several of its members by death, be it therefore

Resolved, that the American Association of Petroleum Geologists in convention assembled express its loss of these splendid men, and further that it transmit to the families expression of its deepest sympathy.

Respectfully submitted,

C. R. MCCOLLOM, *Chairman*
C. W. HAMILTON
JAMES H. GARDNER
WALTER M. SMALL

The following members were appointed as delegates to the International Geological Congress at Madrid, Spain, in May, 1926: Frederick O. Martin, Joseph T. Singewald, Jr., W. E. Wrather, C. R. Thomas, E. H. Sellards, Sidney Powers, Winthrop P. Haynes, Ray P. Walters, E. DeGolyer.

The following officers were elected for the ensuing year:

President, ALEX W. MCCOY
Vice-president, C. R. MCCOLLOM
Secretary-treasurer, F. L. AURIN
Editor, JOHN L. RICH

These, together with E. DeGolyer, retiring president, constitute the executive committee.

The business meeting adjourned.

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

H. W. BELL, recently with the Louisiana State Conservation Commission as supervisor of the minerals division at Shreveport, Louisiana, has accepted a position as petroleum engineer with the Pure Oil Company at Columbus, Ohio.

S. S. PRICE, chief geologist for the Dixie Oil Company at Tulsa, Oklahoma, made a business trip to the Shreveport, Louisiana, district in April.

MARION H. FUNK, recently junior geologist with the Venezuela Gulf Oil Company, has returned to his home in Lincoln, Nebraska.

A. F. CRIDER, chief geologist, and H. G. SCHNEIDER, geologist, for the Dixie Oil Company at Shreveport, Louisiana, were on a short trip in southwestern Texas the past April.

JOHN F. WEINZIERL of McLoud, Oklahoma, and Miss LAURA LEE LANE of Houston, Texas, were married April 3 at the First Presbyterian Church, Houston, Texas.

WALTER L. GOLDSTON, JR., of Dallas, Texas, was a recent visitor in Shreveport, Louisiana.

EUGENE HOLMAN has been advanced to the position of chief geologist of the Humble Oil and Refining Company with headquarters at Houston, Texas. For the past few years, Mr. Holman has been division superintendent in the Shreveport, Louisiana, office of the company.

KENT K. KIMBALL, who for the past two years has been on the geological staff of the Mid-Kansas Oil and Gas Company, has recently resigned from that position to enter into a partnership with H. S. MCMAHON and L. B. WOSK to engage in exploratory operations under the firm name of McMahon, Kimball and Wosk. The new firm has opened offices at 405 National Bank of Commerce Building, Tulsa.

VERNON F. MARSTERS is now located in Albuquerque, New Mexico, where he is acting as chief geologist for the San Juan Land and Oil Company, New York City.

R. R. THOMPSON, for the past six years with the Texas Pacific Coal and Oil Company, has resigned and is associated with Mr. R. S. KING, formerly vice-president of the same company, with offices in Fort Worth, Texas.

JOHN B. KERR has been making investigations of areas in southwest Texas, north Louisiana, southern Arkansas, and northern Tennessee during the past

three months for San Francisco clients. He expects to complete his work in Tennessee very shortly, when he will return to California.

W. K. CADMAN is moving his office from Eureka, Kansas, to Wichita, Kansas, where he will continue his work in consulting geology.

D. R. SEMMES, now associated with E. B. Hopkins, 25 Broadway, New York, sailed May 8 for Rio de Janeiro, Brazil, where he will spend several months making a geological reconnaissance of parts of Southern Brazil.

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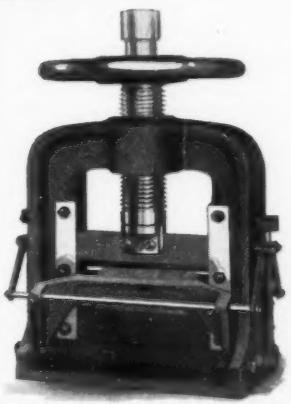

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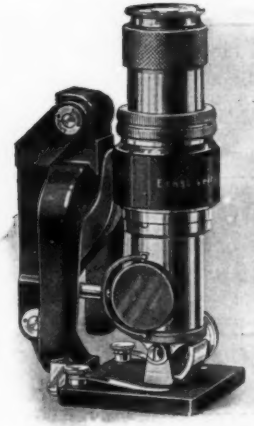

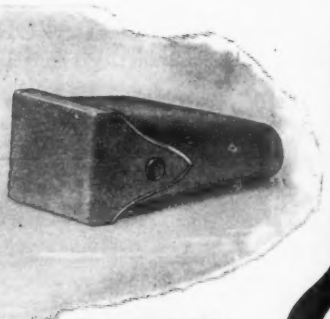

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